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**Ice-Cream Makers**


The making of ices is now effected by machinery, which is increasingly replacing the former manual work. In certain countries, however, connoisseurs are of opinion that really good ice-cream can only be produced when made by hand. This explains why ices made by hand in certain districts, such as Naples and the surrounding country and Sicily, are famous for their good quality.

The occupation of ice-cream maker, by reason of the limited number of operations which it involves, causes certain modifications which may be considered as occupational stigmata. Ferrannini, as the result of investigations among ice-cream makers in Naples, has described in detail modifications consisting of lesions situated on the arms, and strictly related to the mode of working followed by ice-cream makers and to the substances which they manipulate.

The movements which the ice-cream maker is obliged to effect are, for the right hand, manipulation of the spoon with which he prepares the mixture, and for the left hand a circular movement by which he stirs the product in a receptacle containing the freezing mixture. Besides the above, at a given moment he is obliged to pierce the crust which has formed on the surface of the freezing mixture — an operation which he accomplishes with the right hand by means of a wooden wedge (prosciutto). At the same time he adds the necessary amount of salt to the freezing mixture with his left hand, either directly by hand or by using a wooden spatula. As a result of these manipulations, the hands of ice-cream makers show various modifications, chiefly callosities of the skin and wearing down of the nails.

As a result of the continued and violent movement of the spoon, which he holds firmly between the thumb and finger of the right hand, and of the fact that the upper end of the spoon presses against the cubital edge of the wrist, there is formed towards the lower part of the cubital bone a callosity of the skin which extends about 5 to 6 cm. in a vertical direction and 2 to 3 cm. in the transversal. It is generally oval in form, thicker at the centre, diminishing towards the periphery and having a red and rugged surface. This callosity increases in depth with the time spent in the occupation. In the trade it is known as the "cal de la cuillère", "callo del cuchiajo" or "spoon callosity". The palm of the right hand, by reason of the fact that it exerts pressure on the wooden wedge serving to break the crust, develops a more extensive and more irregular callosity situated towards the middle basal part of the hand. It is connected with the internal part of the thenar and hypothenar eminences. This callosity attains a maximum breadth of 5 to 6 cm. and is yellowish in colour. It is known in the trade as the "cal du coin", "callo del prosciutto" or "wedge callosity". Finally, on the palmar surface of the hand and opposite the top of the three middle metacarpal bones and on the palmar surface corresponding to the first phalange there are found small callosities due particularly to the pressure exerted by the handle of the shorter spoon which the worker holds firmly in his hand without letting it rest against the cubital side of the wrist.

The palm of the left hand presents a central callosity corresponding to the part of the hand compressed by the handle which the worker turns when stirring the mixture. This callosity is dark grey in colour when the worker is not engaged on his occupation and turns to flesh colour when he resumes work. This fact is dependent particularly on contact with the salt which the ice-cream maker takes in his left hand.
for salting the mixture. On the back of the same hand, on the phalanges of the third and fourth fingers, there are found small transversal callosities called, in consequence of their situation and their form, "cals de l’anneau", "calli dell’anello" or "ring callosities". These callosities are occasioned by the slight and continual friction of the finger against the external receptacle during the turning movement effected by the worker.

On both hands the nails are eaten away at the edges. The workers declare that it is never necessary to cut their nails. Their permanent contact with salt and ice provides the reason for this state of the nails.

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Incandescent Mantles Industry


Incandescent lighting by gas, petrol or alcohol is based on the fact that numerous solid bodies, especially metallic oxides, yield a bright light when heated by a flame. The amount of light emitted by an incandescent body depends on its temperature, which, again, depends on the equilibrium between the quantity of heat furnished by the flame and that leaving the body by radiation. To obtain the maximum effect, therefore, the quantity of energy radiating to the outside must be slight. It is, however, also necessary that the body rendered incandescent should possess a strongly emissive luminous power.

Cerium oxide has a high emissive power, but it allows a large proportion of energy to be lost by radiation. On the other hand, thorium oxide has only a feeble emissive power, although its loss of energy by radiation is small. The best result therefore is got from a mixture, in suitable proportions, of the oxides of thorium and cerium. Thus, other things being equal, a luminous intensity is obtained 70 times greater than that from pure thorium oxide and 10 times that of pure cerium (Ch. Féry). Manufactured mantles, however, contain a greater proportion of cerium oxide than that stated, because this substance vaporises gradually at a high temperature. A too high proportion of cerium oxide yields a reddish yellow light.

RAW MATERIALS

Thorium and cerium are derived, like several rare earths, from monazite, a mineral obtained principally from Brazil. These two metals are present in monazite in the form of phosphates.

Monazite sand is found in alluvial river deposits or in deposits along the sea shore. The natural sand contains up to 2 per cent. of monazite; it becomes enriched to 60-80 per cent. by washing in the same way as is practised with gold.

Commercial monazite sand is heavy and of a brownish yellow colour. Its value depends on its content in thorium. In view of its density it can be handled in spadefuls without development of too much dust.

The sand, in a very finely pulverised state, is heated with sulphuric acid in a lead-lined vat provided with an agitator. Sulphurous fumes form, and these should be removed as they affect injuriously the respiratory tract; but it is difficult to prevent some escape at the moment the vat is freshly charged with sand.

The product thus obtained, consisting mainly of sulphate and phosphate of thorium, contains in addition numerous metallic impurities and a fair amount of sulphuric acid. It is conveyed in leaden wagons to a fireclay tank where purification is effected by a very complicated process in which the thorium is eventually precipitated as an oxalate by oxalic acid. The metallic impurities are eliminated by different reactions, among which hydrogen sulphide, either in the form of gas or in solution, plays a principal role.

The hydrogen sulphide is prepared in the factory itself from iron sulphide and hydrochloric acid. Occasional cases of poisoning by this gas are reported, the presence of which is revealed by its smell in a dilution of 0.001 to 0.002 per 1,000 parts. Moderate doses of hydrogen sulphide gas cause irritation of the mucous membranes (nose, pharynx, etc.). Its action on the conjunctiva may induce hypersensitivity to light and 0.5 mg. is sufficient to set up in animals bronchial catarrh or pneumonia. According to research on animals and some observations on man by Lehmann, doses of 1 to 2 mg. seriously affect the central nervous system causing loss of consciousness, collapse, and sometimes sudden death. Generally, however, removal of the unconscious individual to fresh air suffices to bring about rapid recovery. Prolonged action of hydrogen sulphide, far from leading to tolerance, increases susceptibility (Lehmann's experimental work and the personal experiences of the chemist Ludwig, of Vienna). Chronic intoxication leads to anaemia, digestive trouble, headache, slowing of the pulse and often diarrhoea and bronchitis.
The solution of oxalate of thorium is precipitated by ammonia; there is formed thorium hydrate, which is converted into the nitrate by evaporation with concentrated nitric acid. Locally applied exhaust ventilation should be applied to remove the nitrous fumes. Thorium nitrate is a white crystalline powder containing a little water of crystallisation.

Some factories make use of a new secret process instead of that with oxalate. This is of interest from the point of view of health, because at one stage in the process cerite is added to the mass undergoing treatment and this produces a crystalline acrustation of acid reaction in the vats, presenting sharp cutting edges. The workers in consequence should wear rubber gloves and clogs to protect the skin when they go into the vats.

The nitrate of cerium is prepared in the mantle factory or purchased from abroad. It is extracted from the residue in the manufacture of nitrate of thorium by a method analogous to that used in preparing the salt: solution, precipitation by oxalic acid, calcination of the oxalate into oxide and treatment by nitric acid (see also article "Cerium").

INDUSTRIAL PROCESSES

To produce the network of the mantle, a tissue rich in ash is obtained and impregnated with a solution of salts of thorium and cerium and then burnt.

The thread of cotton or artificial silk is knitted on machines which present no special danger. Naturally all the moving parts should be guarded, and placing the belt on the pulley should not be done by hand.

The tissue leaves the machine in the form of a long stocking which is carefully washed; it is treated with a 5 per cent. solution of hydrochlooric acid in order to remove the mineral impurities (iron, lime, magnesia), subjected to washing in distilled water, degreasing with ammonia and again washing with distilled water. Drying is effected by centrifugalisig.

The workers manipulating the acid baths as a rule run no risk. The tissue is however sometimes treated with a dilute solution of hydrofluoric acid to eliminate the silicious material. The preparation of this solution from concentrated hydrofluoric acid may be dangerous to the respiratory organs. The risks in connection with the centrifugal machines are recognised. The motor must not be set going until the apparatus is closed, and it ought not to be possible to open it immediately after the motor has been stopped and while the speed of rotation is still considerable. These requirements are achieved by suitable devices, amongst which may be cited those utilising either the draught of a small fan fixed on the axis of the centrifuge or the centrifugal force itself to prevent the opening of the cover. The drying of the stocking is effected in a stove at a temperature of 50° C. and then it is cut by a machine into suitable lengths. The mantles are next hemmed and, according to the particular model for which they are intended (Auer, Welsbach, Grzin lamps), provided with a band of lace or stitching at one end. This work is generally done by an electric sewing machine—rarely by one worked by foot. The mantle is then dipped in the solution of nitrate of thorium and cerium (containing often a little aluminium, magnesium and beryllium) and subsequently passes between the two rolls of a press. The space left between the rolls is calculated in such a way as to leave a definite quantity of the liquid in the tissue. As this machine works slowly there is little risk of getting the fingers pinched between the rollers; in other types of machines this risk is eliminated altogether as the mantles are introduced mechanically. The workers employed at these machines should wear rubber gloves to prevent the skin being attacked by the saline solutions. In small works alternation of employment can be arranged for, so that only short spells are worked at the centrifuges.

The mantles are placed on rests and pass into the dryer and then the upper end is treated with a solution of various metallic salts so as to harden it and enable it to be suspended by the small thread asbestos cord which is threaded on to it. Skill in fixing this thread requires much practice.

The mantles thus prepared are placed in frames and subjected to gas flames which burn the organic matter while the metallic nitrates are converted into oxides. But this operation is not sufficient to give the mantles their desired shape and hardness; they must still be treated in a flame of compressed gas. They can be presented to the flame either mechanically or by hand. Mantles thus heated give out a blinding light and the workers' eyes must be protected by dark goggles or still better by coloured windows in the machine—the last arrangement being preferable as it ensures constant security.

SOURCES OF DANGER

The gas that may escape from the numerous burners and piping constitutes a danger, especially when the
Industrial Health (Propaganda)


Collective hygiene commenced with administrative measures, such as inspection, isolation of those suffering from infectious diseases, and disinfection. Next, material improvements were added, such as general water supplies and drainage, housing reform, provision of baths, douches, etc.

Following on these measures, came the view that a healthy life presupposes a sufficient income. Then hygienists embarked on the economic and social field and associated themselves with efforts seeking to raise the wage level, to abolish unemployment, to give old-age pensions, sums of money in cases of confinement, sums of money in the case of numerous members in a family and to mothers having the charge of infants.

This public hygiene — this social service — is however merely an aid to personal hygiene, which is of fundamental import, since health depends ultimately on daily habits.

Administrative measures, material improvements and social reforms must be completed by the teaching of hygiene. Now this has for its object no less a matter than a reform in the manner of living. Yet to effect this demands a veritable propaganda campaign and the inspiration of an ideal.

The cult of hygiene has passed beyond the purely technical stage to enter on a period of proselytism, and has advanced to the stage at which hygienic measures must be imposed by authority, implying first of all only passive collaboration, which must now however give way to an era of active collaboration, extending over the whole population.

It would be easy to draw a parallelism between this "democratisation" in hygiene, and the analogous evolution noticeable in political life, in industrial life and even in family life, but this would be beyond the scope of this article. Let it suffice to state that active methods have gradually invaded the domains of instruction, education, insurance, the administration of justice, and the regulation of industry, right up to the treatment and care of the sick. Everyone must in the last resort, so say the moralists, work out...
his own salvation. This is true of the body as well as of the soul, and of escape from physical ills just as much as of perfecting of the spirit or of strengthening the character.

Already in a branch of science allied to hygiene, it has been shown that the whole adoption of protective appliances and improved material conditions inside the factory reduce the number of accidents, and it is in the education of the personnel that the greatest measure of success in this respect has been achieved.

It is just the same with hygiene. In order to make its effects penetrate into the lives of workpeople, the sense which the Anglo-Saxons call "a hygienic conscience" must be awakened — a psychological state at once individual and collective, based upon personal as well as general interest.

To arrive at this a technique must be adopted of which the beginnings go back nearly half a century, but which has been developed mainly during the last fifteen years. Its spread has been such that 10-day pamphlets and leaflets on the subject of popular hygiene exist in about fifty languages.

Propaganda on hygiene among workpeople is closely bound up with that intended to reach the general population, the only distinction being that it is addressed to a more homogeneous class as regarded from the aspects of its occupational, economic and social life.

These are the elements which have already been described by writers who have made popular education in the domain of hygiene their particular subject.

As Sir George Newman, Chief Medical Officer of Health in Great Britain, has said with characteristic clearness, popular education in this field embraces three distinct tasks which represent three stages in its fulfillment: first, it must be forced on the attention; then the necessary instruction must be supplied; and lastly it must be given practical effect.

Each of these three tasks requires a different technique: propaganda attracts attention; teaching supplies the necessary instruction; adequate training will enable it to become of practical effect.

Propaganda utilises the methods of commercial publicity, that is to say, illustration by posters, drawings, caricatures, photographs, lantern slides, cinematograph films and pictures.

Teaching makes use of pedagogic methods described as passive (talks, lectures, courses, radio talks; written instruction (notices, leaflets, brochures, articles in papers, periodicals, books); demonstrations (models, exhibitions, theatrical representations, processions)).

Education rests on active teaching methods: influence exerted by the atmosphere under which work is done (cleanliness, ventilation, washing and bathroom accommodation in schools, workrooms and offices); participation in collective efforts on behalf of health, either temporary or permanent (health competitions, health weeks, membership of health societies); and lastly the initiation of personal or family habits under the guidance of a doctor or district nurse.

Some of these methods have an extensive character reaching a wide public, but in an impersonal way; so that consequently the impression they leave is relatively superficial and fugitive; this is the case with radio talks, articles in papers, conferences, posters, films, exhibitions. Others have an intensive influence, because they are directed to the individual and involve a genuine collaboration on the part of the interested parties; this is the case with such influence as is brought to bear by a medical man or district nurse. It is precisely because health demonstrations have both an extensive and intensive character that they constitute the most perfect kind of health education.

The effect obtained, however, does not depend solely on the character of the methods employed, or the perfection of the way in which they are carried out or on the extent of the resources behind them, or even on the number and quality of the personnel engaged.

Any mention of popular instruction and especially of propaganda involves psychology; the nature of the organisation which undertakes this form of education has a direct influence on its prestige and its power of penetration.

Health propaganda will always gain by being associated with authorised representatives of the workers. Sir Claude H. Hill and René Sand were in a position to offer the workers the assistance of the Red Cross at the Third International Labour Conference (held at Geneva on 9 November 1924).

In the U.S.S.R. two original methods are employed: the "Wall Sheet", a large sheet posted on the factory wall on which any of the staff may write questions or ideas; "Mini Police Courts", where an imaginary case is taken up in which the accused has contravened the rules. (See N. Semenius; Protection of Public Health in the U.S.S.R. Paris, International Social Service Conference, 1923.)
Organisers of health demonstrations have based their efforts on the same principle.

Summing up, it may be said that in order to further health among workers two conditions are necessary: good technical equipment, and knowledge of hygiene.

Examples are numerous. It is proposed to give here an account of the most striking ones, commencing with the health of children. The importance of which is paramount because it addresses itself to all those who constitute the future generation and is supplied at the most impressionable age for the formation of right thinking and proper habits.

It takes the form of health education, infant care, domestic economy, physical culture, references to health in the course of other lessons, daily exercise of hygiene at school (washing the hands, brushing the teeth, physical culture, school meals), school medical inspection, visits to health institutions. The League of Little Mothers has united the girls who wish to begin child welfare. The Health Crusade and the Juvenile Red Cross, with a strength of twelve million members in over forty-one countries, are composed of boys' and girls' societies which engage their members to pay attention to daily health.

Programmes of instruction in schools for primary, secondary and higher education, for occupational and domestic training, and the courses held for adolescents and adults have not yet accorded to hygiene the place it deserves even in places of learning for the working classes, the workers' university colleges, those centres of workers' education which are the realisation of their own efforts and ambition; nor again in institutions with which the workers are closely associated, such as the provincial organisations for workers' spare time in Belgium, and the national work carried out by Dopolavoro and the Fasci Femminili in Italy.

To promote popular health instruction in all its forms public authorities in Austria, Germany, Great Britain, the United States, the U.S.S.R. and Yugoslavia have founded State offices, provincial or municipal, which have undertaken work on a great scale. The National Office for Social Hygiene occupies the same role in France. Mention should also be made of the museums for the protection of infant life (Berlin, Budapest, etc.), the travelling exhibitions of hygiene and child welfare (on trains, boats, in motor-cars, and in China on wheels), the village institutes (notably in Russia, where posters and models relating to hygiene and child welfare are exhibited).

On the other hand, medical inspectors of factories, social helpers, who often make periodical examination of the workers or, at any rate, of the young persons in different trades, find excellent opportunity for instruction. Some of the medical services have published pamphlets and leaflets or have organised courses of instruction.

The New York municipal health office has collaborated with all the trade unions to organise, through them, enquiries into hygienic conditions prevailing in workshops and as to the health of each of their members; this is indeed a real piece of personal propaganda in the laws of health. The German Insurance Offices have issued to their members a little book on health matters (Gesundheitsbüchlein) published by the Federal Health Office. Similarly, in England, under the National Health Insurance Act of 1911, the Friendly Societies have devoted part of their funds to health teaching and some of them have made excellent use of this means.

Action is also taken by the sickness insurance societies to attain the same end through their sanatoria, preventoria, their dispensaries and their convalescent homes by teaching health principles.

Among the activities due to private initiative mention should be made of the Red Cross societies, linked up as they are with the League of Red Cross Societies, which supplies data to, and assists in this direction the National Councils on health activities (France), the associations for giving instruction in mental hygiene, maternal hygiene, and child welfare, and for combating tuberculosis, venereal diseases, alcoholism, cancer, heart diseases, and blindness. The Rockefeller Foundation, the Commonwealth and Milbank Foundations, the press, broadcasting stations — these have all given their support.

But the largest development in this direction has been effected by certain American organisations, which have adopted the principle of insurance en bloc of factory staff; their example has been copied by British, German, Czechoslovak and South African insurance companies. In twenty years
the Metropolitan Life Insurance Company of New York has distributed 534,942,654 pamphlets on health matters; its district nurses have made 33,926,064 visits; the films which it has prepared have been shown to about ten million persons.

It provided the funds for the first health demonstration, which took place at Framingham (Massachusetts). Since then the Rockefeller, Commonwealth and Milbank Foundations, the American, Czechoslovak and Belgian Red Cross Societies, the Hungarian, Polish and Czechoslovak Health Services have joined in this effort. These demonstrations are always undertaken in collaboration with the local authorities, medical associations, employers' associations and trade unions. Their object is to supplement the medical services of the locality so as to equip them in the best and most up-to-date way: with policlincs, dispensaries, laboratories, specialists, consultants, district nurses and the means for propaganda and instruction in health matters. Preventive medical examinations are an excellent means of drawing attention to hygiene and are an integral part of the necessary equipment.

In the United States and in Germany medical associations interest themselves actively in teaching hygiene. Naturally it goes without saying that in this respect the family doctor in his daily round can become a veritable apostle in the cause.

Among university institutions, the Industrial Clinic of Milan (Clinica del Lavoro), under the direction of Professor Devoto, takes the foremost place in the role of instructor, for it has not been content merely with the application of medicine in all its branches to industrial medicine, but it has undertaken also the work of propaganda and of teaching, in active collaboration with employers' associations and trade unions.

The university clinics of general medicine themselves are mindful of their duty in the matter of popular instruction. At Cluj in Rumania, Professor Hategan, accompanied by his pupils, makes a tour of the district by motor-car every Sunday, giving lectures on health at different places. In Buenos Aires Professor Carbonell has made it the duty of his pupils to give popular health talks.

Of all the employers' institutions it is without doubt the sickness funds (caisses de compensation), flourishing both in France and Belgium, which have undertaken in the largest and most systematic measure health propaganda among the working classes, thanks to their consultations for mothers and infants and for district nurses.

Individually such employers as have engaged doctors, nurses and welfare supervisors have contributed by these means to the teaching of hygiene; the practice of instituting medical examination prior to employment or, more rarely, of periodic medical examination, the organisation of courses of training in first aid and personal hygiene, and lastly supervision of the sanitary condition of the works — provision of washing and bath accommodation, cloakrooms, mess-rooms, rest-rooms, playing and sports fields — all have a permanent effect on the workpeople in the matter of health.

In several countries employers have formed themselves into associations for the prevention of accidents and for ensuring safety in factories; many of them have published and posted up sheets containing warnings as to health risks.

Certain mutual associations may also be cited, such as notably the Joint Board of Sanitary Control in the Cloak, Suit and Skirt Industry, which, not content with having created its own policlinic and its own system of health inspection of the workshops, organises conferences, distribution of leaflets and visits paid by its staff of visiting nurses.

Finally, what has been done by the workpeople themselves deserves special mention. For a number of years past the American Federation of Labour has shown an active interest in the health of the workpeople. The Workers' Health Bureau of New York was founded by trade unionists to guide and further efforts in this direction, notably in health propaganda. The same idea has prompted the formation of the Friends of Health (Zadru gas) in Yugoslavia.

Mention should be made of what has been done in Belgium in the matter of rural hygiene by the Boeren-bonden and Boerinnen-bonden (farmers' associations for male and female workers).

Almost everywhere the trade union, insurance, and co-operative press has joined in the efforts. Youthful factory workers and union members have engaged in organising health courses and exhibitions, distributing leaflets and showing films.

The workers' friendly societies act in the same sense with their policlincs, their holiday camps, their preventoria and sanatoria, and their district
Industrial Hygiene: Workshops


It is hardly necessary to insist on the favourable influence of good hygienic conditions on the health and life of the worker, and it is for this reason that efforts should be made towards the most extensive application of such measures where it is a question of protecting workers against the risk of disease in general or against specific occupational diseases in particular.

In the most advanced industrial countries legislative measures have already been issued which in their entirety correspond to the demands of hygiene in all modern establishments. In this article there will be enumerated those measures which from a hygienic point of view it is advisable to adopt with regard to the construction and running of a factory.

There may be expected in this connection the raising of the objection that the following account represents a maximum rather than a minimum to be given practical effect. Such an objection, however, should not prevent the utmost importance being attached to these measures and the desire that every possible effort should be made towards realisation of the majority of them in industrial practice.

Whilst it is at times difficult to apply new health measures in old plant or factories which are already working, on the other hand it is usually easy to insist on the adoption of them when an establishment is in course of construction.

It must be remembered that though the provision of hygienic working conditions may seem costly, it represents nevertheless, in the words of the employers themselves, "an expense that pays" (reduction of cases of sickness and accident, improved production, improvement in the workers' health, increased efficiency, etc.).

1 A draft standard code of industrial hygiene has been prepared by the Hygiene Service (1932) and will be submitted to the members of the Correspondence Committee on Industrial Hygiene of the International Labour Office. It must, however, be recalled here that the draft in question is only intended as a vade-mecum for all those who in the different countries are directly interested in hygiene as affecting factories and workers. This article is restricted to passages from the draft edition relative to "workshops", and for questions such as "dusts", "gases and fumes", "personal hygiene", "first aid", "welfare workers", "factory surgeons", etc., the reader is referred to the special articles dealing with these questions. (Dr. L. Carozzi.)

Dr. R. Sand

(Paris)

nurses. Some of them have undertaken — sometimes with the assistance of the Red Cross — a veritable health propaganda campaign among their members.

Yet the workpeople are still far from having exhausted all the possibilities open to them in this field: workers acting as inspectors, sent as delegates to factory committees and joint councils (such workers are frequently trained for the purpose by following special courses) ought to concern themselves more than they do with problems connected with health and health teaching both in and out of season. If the creation of safety councils with workpeople on them has contributed as much as it is claimed to have done in American factories to the diminution in the number of accidents, the institution of similar councils in Europe ought to be able to effect as much.

Health teaching among the working classes is a necessary and wide field calling for all the official and benevolent co-operation possible. But its effectiveness depends on the active participation of the workers themselves.

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The hygienic conditions to which workshops should conform may be classified according to their importance, as follows: (a) general provisions, and (b) special provisions.

Amongst the former are included those which should be required for every workshop without exception, whatever the nature of the work carried on there, whilst the second are applicable to workshops where the nature of the work carried on or the special technical conditions may constitute a risk to the worker's health. In the second case mention will here be confined to giving an account of the measures to be taken in those industries where the industrial technique involves important modifications of the surrounding conditions (high or low temperature, humidity, liberation of dust, steam, fumes, gas, etc.).

**General Provisions**

**Situation and Exposure of Buildings**

The construction of factories in very damp regions or on ground recently drained, in enclosed and narrow valleys or in districts with very high buildings should be avoided as far as possible.

The factory should neither have a distinctly northern, eastern, or western exposure nor should it give on to walls or rocks which may cause annoyance by undue reflection of light. Buildings with three or four free frontages should have their four corners in accordance with the four cardinal points, or their principal axis in the direction N.W.-S.E. If, however, the building has only two contiguous sides free, it is then preferable that the angle formed should have a southern or northern exposure. Whatever the case may be, efforts should be made to avoid a distinctly, eastern or western exposure.

The considerations in question are only of practical value for countries where solar radiation is very strong, since in northern countries effort is made to favour the entry of natural light into the workshops.

In general the number of buildings composing a factory is in proportion to the importance of the establishment and the nature of the operations carried on therein. Nevertheless, it is necessary that the various buildings should be so situated that they enjoy good natural lighting and good exposure as regards sunlight. The most suitable situation is that which also assures good ventilation. For this reason efforts should be made to avoid the construction of closed courts between buildings and construction in an unduly prolonged U-form.

The workshops should be so situated as to assure the maximum of natural light and a minimum exposure to inclement weather. Workshops should be situated above the level of the ground. In exceptional cases the use as workshops of rooms situated below the level of the ground may be authorised, provided they have a sufficient provision of daylight and are protected against damp. In any case, work in a basement which falls short of hygienic conditions required for a workroom on the level of the ground should be prohibited.

**Area.** — The area required for each individual engaged on work in a closed workshop should not be under 2 sq. metres. This figure is a net figure, i.e. without deduction for furniture, machinery and fixtures.

**Height.** — The effective height for working premises should be at least 3 metres when the surface does not exceed 100 sq. metres.

**Air space.** — In closed working premises air space should represent at least 10 cubic metres for each person employed.

In the calculation of this volume the parts of the premises above a height of 3.50 metres shall not be taken into account. Furthermore, the figures relating to the air space should be taken as a net figure without deduction for furniture, machines or fixtures. It must also be recalled that the surface, the height and the air space of the workshop are in strict relation to the number of persons employed, ventilation, the nature of the work effected, the presence of internal-combustion motors, etc.

**Floor, Roof, Walls and Ceiling.**

The type of flooring in workshops varies according to the nature of the work carried on. The flooring should not be situated below the level of the ground, save in cases where special exception has been granted. In the latter case insulation of the ground, lighting and ventilation should be such as to fulfil health requirements. The flooring should be thick, solid, smooth but not slippery, firm and

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1 The problem of factory construction was discussed at the annual meeting of the German Society of Industrial Hygiene (Heidelberg, 1929). See the reports presented at this meeting and in particular the principal report submitted by Prof. Hahn and Eisenberg.
watertight, allowing the removal of dust without difficulty either by flushing with water or aspiration. Wooden flooring must be protected against moisture (see articles "Chemical Trades" and "Nitro-Amido Derivatives").

The roof must be arranged in such a way as to prevent the workspaces being overheated by solar heat, cold, rain and wind. Rooms situated under the roof must not be used unless the roofing is constructed in such a way as to prevent overheating.

The walls and the ceilings of all workshops should have a smooth and impervious surface capable of being cleaned and so constructed that they constitute bad heat conductors. In certain cases it is advisable that the walls should be coated with a washable paint applied up to about 2 metres from the ground. The walls and ceiling should be whitened or washed twice a year.

In workshops where great quantities of liquid or organic matters are handled, it is advisable to paint the walls and ceiling, which must be maintained in good condition.

The walls must be protected against dampness from the ground and must be weatherproof.

Apertures, Windows and Doors

Premises should be furnished with windows, which must be adequate in number and size to admit the requisite quantity of light to all parts of the workroom. The windows should be constructed and situated in such a way that they can be opened and easily cleaned. They should be furnished with a sufficient number of movable adjustable panes, unless there exist other means of ventilation. The ratio be-

1 The Association of British Chemical Manufacturers in 1929 issued a pamphlet containing hygienic measures for application in the chemical industry. Whilst this pamphlet presents hygienic measures of a general nature, there will be given in a later pamphlet those connected with certain special branches of the chemical industry.

2 Working premises with lighting sheds and without windows in the wall are no longer regarded favourably by hygiene experts. Whilst this type of building gives, it is true, a uniform light free from dazzle, it is deprived of the advantage of large windows which constitute a pleasant element by reason of the outside view provided. It is for this reason that preference is now increasingly given to construction with several floors where walls are almost entirely constituted of large windows with glass panes close to each other.

3 The windows should be so arranged that they open, wherever possible, on the opposite sides of the workroom or are situated opposite continuous walls. Their arrangement should be as effective as possible, with a view to facilitating ventilation of the workroom, which is not the between the surface of the windows and that of the floor of the working premises shall be less than 1:6 (see article "Industrial Lighting").

Measures should be taken for the protection of workers against excessive sunlight and solar radiation during the hot season.

The entrance to working premises must be furnished with doors opening outwards, close fitting and closing automatically. Sliding doors should not be permitted unless the workshop is already provided with a door opening from within outwards. Doors which open in both directions should be provided with a transparent glass pane enabling persons arriving from the opposite side to be seen.

Cleanliness of Premises

Cleanliness is best attained by avoidance of soiling. Effective measures should therefore be taken for preventing soiling of the flooring, walls, benches, tools, etc. Each workroom should be kept in a perfect state of cleanliness, and as far as possible protected from the production of dust and damp. The flooring, as well as the walls, the ceiling, benches and machines, should be periodically cleaned by the wet method outside working hours. For these purposes brushes or damp cloths, and the exhaust system of cleaning (vacuum cleaner) should be used where working conditions or the nature of the flooring do not permit of flushing with water.

Ventilation

In every workshop there should be openings of a suitable size which, by their situation, permit of the circulation of air, and thus assure permanent and efficient ventilation in all parts of the room. Premises must, in addition, be thoroughly aired at least once a day (during the midday rest period, for instance).

Lighting

Workrooms should be adequately lighted. Illumination of the room should be improved on all occasions on which circumstances permit by white-washing of the walls, or at least of the case in working premises with sheds or those which possess a single row of windows. If the workroom is very high, it would be advisable to have two rows of windows, one above the other. The windows wher possible should be constructed with sliding panes in preference to French windows. Draughts should be eliminated by adopting special types of panes for ventilation purposes (casting system, ventilating panes, etc.).
upper part of the walls, or by any other reasonable means. The sources of artificial light should not function in such a way as to increase to a considerable extent the carbon dioxide content of the atmosphere during working hours. In order to endow natural or artificial lighting with its total efficiency, the panes of the windows and the globes of lamps should be kept in a state of irreproachable cleanliness. In a workshop possessing a central station for the production of artificial light, precautions must be taken for replacing this lighting in cases of accidental failure of the central installation. In order to meet the requirements of adequacy and efficiency the lighting must fulfil certain special demands (these are dealt with in detail in the article "Industrial Lighting").

Temperature

As far as the type of work executed permits of it, the temperature of working premises must be maintained within suitable limits.

In closed workrooms the temperature should not fall below 15° C. In summer the working premises should be protected against excessive heat. A thermometer must be placed in every workroom, and kept in good working order. In estimating the temperature suitable for the workers, account must be taken of the influence exercised by hygrometric conditions and the air movement (see article "Air: Hot and Humid Atmospheres"). In order to reduce the trying influence of excessive sunlight in summer, the windows may be provided with blinds, or given a blue or at times a white coating. There may also be adopted a yellow coating inside and a blue outside.

Heating of the premises should be ensured during the cold season. The heating apparatus must be furnished with appliances ensuring the regular elimination of gases produced by combustion. Regulation of the heating apparatus by means of keys or dampers which can completely close the pipes for elimination of gases and fumes should be forbidden. Radiators and heating pipes must be installed in such a manner that the workers are not inconvenienced by radiation of heat or by circulation of hot air (see article "Heating").

Special Provisions regarding Hygienic Conditions

Flooring and Inside Walls

In working premises (chemical industry, dyeing industry, tanneries, etc.) where putrescible or liquid substances usually soil the flooring, the latter must be sufficiently inclined to allow the liquids to flow rapidly towards the collecting points for evacuation. Unless workers are provided with clogs or waterproof footwear, the wet flooring at working posts and in passageways should be permanently fitted with lattices or gratings. In the case of stone flooring, working posts where workers are obliged to stand continuously should be provided with matting or other covering as protection against the cold. In workrooms in which dust, smoke, gas and fumes are liberated, the inside walls should be so constructed that these irritants are prevented from penetrating into other parts of the establishment. The interior walls and the ceiling should be so constructed that steam does not produce condensation.

Ventilation

In every workshop, in which it is impossible to ensure adequate natural ventilation, recourse must be had to artificial means of ventilation. Ventilation of this type cannot be considered effective unless the air is renewed completely at the rate of at least 30 cubic metres per hour and per worker. The disposition of ventilators should not be such as to inconvenience the workers by directing a draught towards them. The air supplied should have an average temperature of not less than 12° C. In premises and establishments in which work is specially unhealthy, the air renewal rate should be at least 60 cubic metres per hour and per worker (see article "Ventilation").

Temperature

In workrooms where industrial technique involves the production of excessive temperature — unduly high or unduly low — which it is impossible to modify, adequate measures should be taken to protect the workers.

Stalls outside shops must be furnished with awnings or other means of protection for the workers there engaged against the inclemency of the weather (see article "Temperature").

1 It is not now considered advisable to construct very extensive workrooms for a large number of workers, since ventilation in these offers difficulties, especially where workers are engaged on different processes. There is also a whole series of obstacles from the technical point of view. Similarly, attempts should be made to avoid working in a single workshop workers engaged on operations involving different occupational risks.
Humidity and Humidification

In workrooms where the atmosphere requires artificial humidification (flax spinning, wool spinning) two standardised humidity thermometers should be posted, one in the middle of the workroom and the other at a suitable spot.

Wherever artificial humidification is practised, the wet bulb thermometer should not mark more than 24° C. On the other hand, the dry bulb thermometer should mark a temperature of at least 10° C. In any case the reading of the wet bulb thermometer should not approach too closely that of the dry bulb thermometer. The water used for humidification should not contain substances or germs endangering the health of the workers (see article "Air: Hot and Humid Atmospheres").

Dust

Processes which liberate or raise dust of any kind whatsoever in the workroom should, as far as possible, be executed in closed apparatus provided with exhaust ducts. In default of this, such processes should not be engaged in, unless adequate means are provided for catching the dust as it is produced, as near as possible to the point of production. The dust should further be removed and disposed of in a manner excluding its dispersal in premises where workers are employed. It should then be subjected to treatment calculated to render it innocuous.

Withdrawal of dust by the exhaust process should be per ascensum or descensum, according to the nature of the dust in question. Apparatus and pipes used for ventilation should be solid in construction, made of material impervious to dust and so disposed as to be easy of access for purposes of inspection and cleaning. Pipes for dust withdrawal should be maintained in a condition allowing uninterrupted circulation of the dust.

Wherever it is compatible with the requirements of industrial technique, and in order to prevent the liberation and diffusion of dangerous or noxious dusts, the raw material, as well as the finished products, the floor, the inside walls, and all parts of the premises most exposed to the settlement of dust, should be kept in a suitable state of dampness by means of frequent sprinkling with suitable liquids (see article "Dust, Fumes and Smoke").

Steam, Fumes, Gas and Liquids

In workshops where steam is produced, there should be installed hoods or chimneys, or other effective apparatus, for its elimination (see article "Dyeing"). Processes involving liberation of fumes or noxious gases should be executed in closed apparatus, provided with an efficient draught, or under a hood provided with a movable glass shutter. Irritating or otherwise noxious fumes or toxic gases should not be freely liberated in the atmosphere until they have first been subjected to adequate processes of condensation, neutralisation, saturation, or pyrogenic transformation, as the case may be, in order to render them inoffensive for the neighbourhood (human beings, cattle, vegetation).

Workers should not be permitted to enter wells, cisterns, reservoirs or other similar containers, before it has been made certain that no asphyxiating, harmful or inflammable gases are present. Where such gases exist, the atmosphere must first be purified and all absence of danger must be assured. Where this cannot be done, workers should not be permitted to enter unless provided with effective protective apparatus and having a safety rope round the body. Furthermore, workers employed in such a case should not be permitted to enter one at a time and should work under the supervision of a responsible person outside. They should be relieved as often as the circumstances permit. The necessary personnel and material for affecting rescues in case of need should remain in close proximity to the work, and should be available for its entire duration.

When toxic or corrosive liquids are used in an establishment they should be kept in such a manner as not to constitute risk for the health of the workers. Their circulation should be assured by aspiration or by pressure. (See articles "Air: Hot and Humid Atmospheres" and "Gases and Fumes").

Smoke, Odours, Emanations, Residual Water and Waste

In closed workrooms, where under normal circumstances smoke of any kind whatsoever is liberated, adequate means should be taken to eliminate or reduce as far as possible its production and its diffusion throughout the atmosphere in which workers are obliged to remain. Wherever circumstances permit, special processes should be adopted with a view to precipitation or to maximum combustion.

In workrooms in which odours of
any kind whatsoever are given off, measures should be taken for aspirating these as completely as possible in the immediate neighbourhood of their production. On the other hand, all accessory installations which may constitute sources of pollution of the air should be constructed and maintained in such a manner that their emanations may not cause a noxious effect.

Waste and residues of manufacture, debris from raw material, sweepings, and in general all waste matter should be removed at the end of each working day or working shift from the workshops, collected and regularly evacuated, burned or buried, without possibility of giving rise to nuisance.

Waste waters should be regularly withdrawn by an effective system of drains provided with hydraulic traps or syphons, and frequently washed. In cases where residual water cannot be conveyed to a drain, it should be submitted to suitable treatment before being directed outside or into any water course (see articles "Dusts, etc.", "Odours" and "Industrial Waste Water").

**Noises, Vibration and Shocks**

In industries giving rise to shocks, vibration or noise prejudicial to the health of the workers, effective measures, counselled by technical experience, to diminish their intensity, should be adopted. At the same time care should be taken not to expose needlessly those workers not directly employed on such processes. (See article "Noises").

**Legislation**

The Medical Service of the Italian Factory Inspectorate (Minister of National Economy) in 1928 published a pamphlet in which the factory inspector, the employer and the worker may find analysed in a simple and exact manner the measures issued by the Regulations on industrial hygiene (1927). This pamphlet constitutes a highly essential vade-mecum of practical industrial hygiene.

The legal measures relative to hygiene in workshops which have just been described in brief are to be found scattered throughout laws relative to protection in industry or assembled in special laws. The latter exist in the most advanced industrial countries, amongst which may be noted Austria, Belgium, France, Germany, Great Britain, Italy, the Netherlands, and Switzerland. The following list should be of use to the reader as a summary account of the laws, regulations, orders, etc., relating to these eight countries.

**Austria**

**Laws**


**Orders**

I. Of 23 November 1905 relative to the amendments and additions made in the Labour Code and the general measures for the protection of the life and health of workers.

II. Of 29 May 1908, issued by the Ministers of the Interior and of Commerce, regulating industrial work in stone quarries, clay pits, sand pits, and ballast holes.

III. Of 23 August 1911 issued by the Minister of Commerce, in conjunction with the Minister of the Interior, containing special provisions relative to the safety and hygiene of the workers in industrial establishments in which printing processes, lithography and typefounding are carried on.

**Belgium**

**Laws**

Act of 2 July 1899 concerning the safety and health of workers in industrial and commercial establishments.

**Royal Orders**

I. Of 30 March 1905, prescribing measures to be observed with a view to protecting the health and safety of workers in Industrial and commercial establishments, subject to the Act of 24 December 1905.

II. Of 5 November 1910, relative to the manufacture of white lead and other lead compounds.

III. Of 15 January 1914, relative to the manufacture of white lead and other lead compounds.

IV. Of 15 May 1923, regarding supervision of dangerous, unhealthy or noxious trades.

V. Of 12 March 1923, regulating work in zinc factories.

VI. Of 20 March 1926, relative to personal cleanliness, and prescribing conditions connected with the use of heating apparatus situated in working premises engaged in dangerous trades.

VII. Of 28 June 1929 prescribing the measures to be observed with a view to protecting the health and safety of workers in Industrial and commercial undertakings, subject to the law of 24 December 1928.

**Ministerial Orders**

I. Of 26 January 1914, regulating work in compressed air caissons.
France

Labour Code

Laws

I. Act of 19 December 1917 relative to dangerous, unhealthy or noxious trades.

Decrees

I. Of 10 July 1913, amended 29 March 1914 and 23 October 1917, concerning general measures of protection of health, applicable to all establishments coming within the law.

II. Of 1 October 1913, concerning special measures of hygiene applicable in industries where the workers are exposed to the risk of lead poisoning.

III. Of 1 October 1913, relative to special measures of hygiene to be applied in hair-cutting establishments.

IV. Of 17 December 1918, containing public administration regulations in virtue of section 6 of the Act of 19 December 1917, relative to dangerous and unhealthy or noxious trades.

Germany

Laws

Industrial Code of the German Empire, published by an Order of the Chancellor dated 26 July 1900, and amended by the Acts of 30 May, 29 June, and 8 December 1908, and of 27 December 1911.

Orders

I. Of 30 July 1897, relevant to the conditions of hygiene in typesetting establishments.

II. Of 1 March 1902, relative to the installation and working of establishments for vulcanisation of rubber.

III. Of 22 October 1902, relative to the installation and working of horsehair spinning establishments, workrooms for dressing of skins and bristles, and brush and shaving brush factories.

IV. Of 16 June 1905, relative to the installation and working of lead foundries.

V. Of 27 June 1905, relative to painting, whitewashing and lacquering establishments.

VI. Of 17 February 1907, relative to the installation and working of cigar factories.

VII. Of 16 May 1907, relative to the installation and working of establishments for the manufacture of alkaline chromates.

VIII. Of 6 May 1908, relative to the installation and working of establishments for the manufacture of electric storage batteries by means of lead and lead compounds.

IX. Of 31 May 1909, relative to the installation and working of quarries and stone-cutting yards.

X. Of 3 July 1909, relative to the installation and working of industrial establishments in which basic slag is pulverised, ground or stored.

XI. Of 13 December 1912, relative to the installation and working of zinc mines and factories for roasting zinc ore.

XII. Of 27 January 1920, relative to lead colours.

Great Britain

Laws

I. Act of 17 August 1901 on factories and workshops.

II. Factory and Workshop (Cotton Cloth Factories) Act of 17 August 1911.


Orders

I. Of 4 February 1913 on sanitary conditions of workshops.

II. Of 18 March 1912, on hygrometers in the cotton industry.

III. Of 9 October 1917, No. 1068, relative to drinking water in certain factories and workshops.

Regulations

I. Of 19 June 1903 on file-cutting by hand.

II. Of 19 January 1925 on the electric accumulator industry.

III. Of 12 December 1905 on sorting, willeying, washing, combing and carding of wool, goat hair and camel hair, and processes incidental thereto.

IV. Of 26 February 1906 on spinning and weaving flax and tow, and processes incidental thereto.

V. Of 21 January 1907 on manufacture of paints and colours.

VI. Of 6 August 1907 on heading of yarns by means of a lead compound.

VII. Of 28 August 1907 on spinning and weaving hemp or jute, or hemp or jute tow, and processes incidental thereto.

VIII. Of 20 December 1907 on the use of horsehair.

IX. Of 20 June 1908 on casting of brass.

X. Of 18 December 1908 on vitreous enamelling of metal or glass.

XI. Of 30 June 1909 on tinning of metal hollow-ware, iron drums, and harness furniture.

XII. Of 2 September 1925 and 26 October 1925 on grinding of metals.

XIII. Of 12 August 1911 on smelting of metals containing lead, on the manufacture of red or orange lead, and on flaked litharge.

XIV. Of 11 April 1912 on bronzing with dry metallic powders in letterpress printing, lithographic printing, and coating of metal sheets.

XV. Of 2 January 1913 on the manufacture and decoration of pottery.

XVI. Of 23 August 1912 on the manufacture of certain compounds of lead, viz.
any carbonate, sulphate, nitrate or acetate of lead.

XVII. Of 29 December 1921 on the handling of dry or dry-salted hides or skins.

XVIII. Of 31 March 1922 on the manufacture of indiarubber and articles made entirely or partly of rubber.

XIX. Of 11 July 1922 on chemical works.

**Italy**

General Regulations on industrial hygiene of 14 April 1927, No. 530.

**Netherlands**

Laws

Act of 19 June 1915 on safety.

Royal Orders

I. Of 10 August 1920 issuing General Administrative Regulations in application of subsection (10) of section 1 of the Act of 1919 on the work of women and young persons.

Decrees

Of 27 June 1913 replacing the Decree of 7 December 1893 modified by the Decree of 10 June 1909 issuing Public Administrative Regulations in application of sections 6 and 7 of the Act on safety.

**Switzerland**


Apart from these Acts and Regulations, etc., of which a particular analysis has been given by way of illustration of the present article, there exist also in other countries legal measures connected with hygiene of working premises. Amongst these may be mentioned:

**Argentina**

Decree of 19 November 1928 relative to hygiene measures in industrial establishments.

**Brazil**

Decree No. 3876 of 21 July 1925 on the reorganisation of the Department of Public Hygiene (Chapter III: factories in general and factory inspection).

**Chile**

Decree No. 217 of 30 April 1926, containing regulations on industrial hygiene and safety.

**Ecuador**


**Hungary**

Decree No. 91560, 1926, of the Minister of Social Insurance relative to the study of hygienic conditions in factories.

**India**

Factory Act of 1911, amended 25 March 1926 (No. XXVI, Chapter 3).

**Japan**

Order No. 28 of 20 June 1929 of the Minister of the Interior issuing Regulations relative to safety and hygiene of workers.

**Luxembourg**

Act of 28 August 1924 relative to the health and safety of workers engaged in industrial and commercial establishments.

**Mexico (Campeche)**

Factory Act No. 57 of 29 November 1924 (Chapter 16).

**Peru**

Decree on measures of industrial hygiene and safety of 29 January 1926.

**Poland**

Legislative Decree adopted 1 March 1928 by the Council of Ministers on Industrial Hygiene.

**U.S.S.R.**

Orders Nos. 105 to 512 of 8 April 1928 relative to factory inspection (sections 34 to 36, 38, 82).

**Uruguay**

Order of 7 October 1925 on health services in industrial establishments.

**Yugoslavia**

Regulation on industrial hygiene and safety, 1921.

**REFERENCES**

The various measures of industrial hygiene reviewed above are to be found for the most part in the various texts referred to under legislation. References in this connection are given below:

**Situation.** — Switz. O., sec. 54. In the laws of other countries legal prescriptions relative to the situation of working premises have been edicted on grounds of public hygiene and not on those of industrial hygiene. It is a question of isolating or placing at a distance from inhabited areas constructions intended for industrial establishments.

**Area.** — Aus. O. I; It. R., sec. 8.

**Height.** — Aus. O. I; Bel. R.O. I, sec. 3, subsec. (2); It. R., sec. 8; Switz. O., sec. 54.

**Cubic air space.** — Aus. O. I, Bel. R.O. I, sec. 3; Fr. D. I, sec. 5; G.B. A. I, sec. 3; It. R.; Neth. R.O. I, secs. 16 and 37; Switz. O., secs. 32 and 54.

**Flooring.** — Aus. O. I, secs. 3, 4, 5; Bel. R.O. I, sec. 13; Fr. D. I, sec. 2; Ger. O. I,

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**Explanation of abbreviations:**

Aus. Austria; Bel. Belgium; Fr. France; Ger. Germany; G.B. Great Britain; It. Italy; Neth. Netherlands; Switz. Switzerland; M.O. Ministerial Order; R.O. Royal Order; D. Decree; A. Act; O. Order; R. Regulation; I, II, III, order of the various texts in the list given under "Legislation."
INDUSTRIAL LIGHTING

The importance of suitable lighting in industry is obvious. But employers and technicians should not be obliged to grope about to find the standard of lighting suitable for their works, and at the same time the indefiniteness which still characterises certain regulations should be remedied.

Suitable lighting leads to cleanliness of workplaces, postponement of fatigue, prevention of accidents, easier discipline and control, limitation of waste, and better quality of work with more rapid production.

The use of electricity has for some years increasingly favoured the use of artificial lighting, with a tendency to use a very much higher standard of illumination than that recommended by hygienists. This is easily understood, having regard to the progress made in the production of light.

Undoubtedly the problem of general lighting, and industrial lighting in particular, presents aspects which have not yet been elucidated and calls for fresh experiment. But all the same, it has been possible to fix some rules which are applicable to the daily work and, for economic and hygienic reasons, ought not to be ignored.

**Sources of Light**

Powerful lights give the sensation which we call "white". While the normal eye only perceives the middle or luminous part of the spectrum, it cannot escape in the same way as the against noise, etc., have as their object: the safeguarding of the neighbourhood and not of the workers engaged in the industry.

**Waste water, refuse.** — Bel. R. O. I, sec. 11; Fr. D. I, sec. 3, subsec. (2); Ger. A., sec. 120a; It. R. sec. 26; Switz. O., sec. 36.
body does from the influence of obscure chemical and physical radiations present at the two extremities of the spectrum, at the dark or infra-red, hot end spectrum, and at the dark, chemical or ultra-violet end.

The sources of light used in practice offer a wide spectrum that is a mixture of various radiations which, when they reach the eye, give the sensation of a single colour, depending on the greater or lesser width of the spectrum and on the comparative intensity of its various parts.

Illumination may be natural or artificial.

Natural Light

Light from the sky is essentially a diffuse light. As a matter of fact, the terrestrial atmosphere contains an infinite number of small particles in suspension which reflect luminous rays in every direction.

Solar light is very rich in ultra-violet rays, most of which are arrested by the atmospheric layer, and also in blue rays.

Natural illumination or daylight is extremely variable. The conditions which influence the illumination most are represented by the seasons, the time of day, the meteorological conditions and the extent of the vault of the sky from which the light is coming. Thus L. Bargeron at 3 p.m. in cloudy weather found 185 lux on the windowsill of a workshop on the ground floor in a large Parisian courtyard, and, in similar weather, on a large square, 2,300 lux at noon and 3,500 lux at 1.30 p.m. The brightness of the sky varies a good deal under different meteorological conditions. It is greater when the blue is not seen. The American Lucifer Prism Company classifies these conditions of brightness into five groups:

1. Nimbus clouds, without blue sky or sun.
2. Cloudless sky, light blue, approaching rain or slight haze.
3. Sky for the most part blue, high clouds: cirrus.
5. Sky entirely covered with clouds, no blue sky.

Artificial Light

The sources of artificial light may be classified as follows:

1. Sources the incandescence of which is due to carbon in flames produced by the combustion of solid matter (such as wax), of liquids (such as vegetable and mineral oils and petroleum), or of gases (such as coal gas, water gas, mixed gases or acetylene).

2. Sources the incandescence of which is due to heat caused by the passage of an electric current, e.g. the incandescent mantles heated by gas or acetylene, or by vapours of other substances, such as spirit; incandescent lamps with filaments with selective power of emission or placed in a special gas, such as nitrogen in the Nernst lamp.

3. Sources the incandescence of which is due to the combustion of various substances, or to the passage of an electric current through a solid body with selective power of emission, e.g. incandescent mantles heated by gas or acetylene, or by vapours of other substances, such as spirit; incandescent lamps with filaments with selective power of emission or placed in a special gas, such as nitrogen in the Nernst lamp.

4. Sources in which the incandescent body is a vapour traversed by the electric current, as in the mercury vapour lamp.

The brightness of the flame in the first group is due to the presence of particles of carbon, made luminous by incandescence. The flame shows below a bluish part which resembles a sheath round the flame where the gas is completely burnt; inside the flame is the luminous part where the combustion is less complete.

A flame gives out light when the particles of carbon are in sufficiently great number and the combustion, without being complete, is sufficient to make the particles incandescent.

When a flame gives out light under normal conditions, its brightness depends at once on the density of the solid particles and their temperature. In order to obtain maximum brightness, the temperature of a flame must be so raised that a maximum amount of the energy radiated by the particles approaches that of the visible spectrum. All substances do not follow the same law of emission.

The more the light proceeding from a luminous body is intense, the higher is its temperature; the more the brightness of the light increases, the more its spectrum extends in gradual stages towards the violet. Increase in lighting capacity is thus accompanied by an increase in chemical rays, especially in ultra-violet rays.

Measurements and Photometric Units

Light has always been measured by comparing it to another light, taken as unity. Violle in 1889 proposed to unify photometric measurements by comparing
them to a platinum standard, of which 1/90 is fairly well represented by the "international candle", which stands in a simple relation to the unit used in Germany and Switzerland. There shall now be briefly summarised the definitions of measurements and photometric units, among which come first "the luminous flux", as the fundamental measurement in photometry, and then a definition of a corresponding unit: "the lumen".

The "luminous flux" is regarded as the fundamental measurement in photometry. The luminous flux (F) is the output of radiant energy estimated according to the luminous sensation which it produces; this definition is adopted by the International Commission on Lighting. The "flux" is the quantity of light given off by a luminous source per unit of time. The flux is then what is commonly called "the light".

The flux emitted by a luminous source is measured by a unit which is the lumen, that is to say the quantity of light which passes through an opening 1 sq. m. in surface, cut out on a sphere with a radius of 1 m., at the centre of which burns a source of light having the intensity of one candle in each direction.

The lumen may be defined as "the luminous flux intercepted by a surface of 1 sq. m., each point of which is situated at a distance of 1 m. from the source which is equal to a decimal candle".

The luminous intensity of a fixed source in any direction is the luminous flux per unit solid angle emitted by the source in that direction. The unit of intensity is the "international candle" or "decimal candle", which is estimated by means of photometry.

The luminous flux is referred to a surface which either receives it or emits it at a density which is called "illumination" when the light is received by the surface, and "emission" when it is emitted by this surface.

Illumination is the effect of light on objects; it is measured by a unit called "lux".

Lux is the illumination produced by a luminous source of a decimal candle on a level surface distant 1 m. at the point where this level surface is met by a luminous ray perpendicular to it. It may also be defined as the illumination produced on the surface of a sphere of 1 m. radius by an exact uniform source of an international candle placed at its centre. If the centimetre is taken as the unit of length, the unit of illumination is then the "phot" which equals 1 lumen per square centimetre, and, if the foot is taken as the unit of length, as in Great Britain and the United States, the unit of illumination is the lumen per square foot, called "foot candle". The "foot candle" is then equal to 10.764 millilux, and to 10.764 lux, being approximately 1 millilux or 10 lux.

The relation between "lux" and "lumen" is such that, if a lumen is used so that its light illuminates a surface of 1 sq.

**The Practice of Lighting**

**Natural Lighting**

In order to make sure beforehand of the light to be obtained from diffuse daylight, it is necessary to take into account the orientation of the workplaces.
Natural lighting in modern factories is usually well arranged and admitted through large openings either in the walls, or in the case of one storied buildings in the roof by skylights. The best way to admit light rays is from above through a glazed roof; but this system is often insufficient or excessive, depending on the season and the weather.

Unilateral lighting from the left side is adopted for schools; bilateral lighting involves a play of shadows and is only of secondary interest from the hygienic point of view. Lateral lighting can be combined with top lighting. Any combination of natural illumination with artificial gives a false and tiring light, due especially to reflections on the cornea.

The best system of lighting for one-floor buildings is that of the saw-roof used for weaving sheds. The glazed part should face north and have an inclination of 40° to 45°. For structures which cover a large area, these rooflights admit light which descends vertically into places where oblique rays, entering by windows, do not penetrate.

Windows should be as large as possible and reach to the ceiling. The distance from the window to the ceiling should never be more than 20 cm. The lower panes should be frosted up to 1.75 m. from the floor. The relation between the height and the depth of the place should also be taken into account, since illumination is inversely proportional to the square of the distance which separates the point under consideration from the wall containing the window.

Obstacles which interfere with the penetration of luminous rays, or which modify their direction, such as buildings in front of windows, should be taken into consideration.

Illumination is also modified by the glass, blinds, curtains, the colour of the walls and ceiling of the room, and by the colour of the front of the building opposite.

Next to white in varying shades, yellow is the colour which presents most luminosity. With white, light yellow, or pale grey, walls reflect from 50 to 15 per cent. of light without dazzling. Whitewashed walls are highly suitable. For the ceiling, by preference a varnish of zinc white, tetanium, etc., is used. Dust and dirty walls interfere with illumination, and may reduce the effective luminous flux of the lighting system.

The arrangement of machinery in
workplaces should be studied in order to avoid shadows cast by the workmen. To sum up, natural lighting should satisfy the following conditions:

(i) The greatest possible amount of light should reach as far as the central part of the room;
(ii) The light should fall on the place of work in the most convenient direction;
(iii) The distribution of light on the place of work should be as uniform as possible;
(iv) The walls and fittings of the room should have a colour and surface which will only absorb a small amount of the incident light;
(v) Machines and accessories should be placed so as to cause as few inconvenient shadows as possible.

**Artificial Lighting**

Artificial lighting should supply a light which resembles natural light as much as possible.

The illumination should be generally diffused, that is to say, it should not leave any part of the room in darkness nor cause obstructive shadows; it should be adequate and constant, and should avoid dazzling, either directly from the source or indirectly due to reflection from a smooth polished surface.

Three systems of illumination are in vogue at the present time: the direct system, the semi-indirect system, and the indirect system.

The direct system is that in which the source of light is visible from the place of work and distributes to it most of its rays. The light should be provided with a reflector. The direct system may be used for general, localised or mixed illumination.

The semi-indirect system screens the light from the eyes by a semi-opaque material through which the rays reach directly the place of work, whilst a part arrives indirectly by reflection from the walls and ceiling or from another reflector placed above the light. When the reflector is made of a material which has a high transparency value, the system approaches direct lighting; if, on the contrary, the degree of transparency is low, the effect approaches the indirect type.

The indirect system is that in which practically all the rays reach the working site indirectly by reflection from the ceiling and from the walls. It is obtained by putting below the light an opaque or only slightly transparent reflector which directs all the light to the ceiling. This system, which is very costly, presents great advantages, especially for work requiring great visual acuity. If well installed, it may be superior even to daylight in that it is less tiring to the eyes. Moreover, it obliterates contrasts and sharp shadows, and does away with the accommodation of vision.

Good diffusion of light may be impeded by too low a ceiling. The placing of lights should be carefully calculated so that the ceiling may be lighted as uniformly as possible.

The semi-indirect and indirect systems are most agreeable for the eye, for they allow of the elimination of part of the ultra-violet rays. It is essential that the lamps used should be kept absolutely clean.

The quality of the glass and the type of globe are also of great importance.

Indirect illumination yields a result which is a third of that supplied by direct lighting. But the diminution of waste and the reduction in accident risk make up for the extra costliness of this system. In order to reduce loss of light by absorption, work tables and walls should be painted white, and good use should be made of transparent reflectors made of white translucent porcelain. The loss can thus be reduced by a third.

The system of lighting by incandescent gas may be looked upon as an indirect system of lighting.

As regards diffusion of light, the mercury lamp is the most satisfactory system of lighting. The best results are obtained by combining general lighting with mercury lamps and localised lighting above each work bench.

Artificial sources of illumination should supply intense light without dazzling the eyes, while throwing shadows that are not too sharp.

From the practical point of view a source of artificial light — which, according to Fortin, ought to realise the synthesis of daylight — should have the following characteristics:

It should (i) be easy to use and not be too costly; (ii) resemble daylight as much as possible as regards steadiness, intensity (constancy), regularity (absence of variations in the illumination) and the spectrum; (iii) be poor in ultra-violet rays; (iv) have a moderate brilliance, but a sufficient surface for radiation; (v) not increase appreciably the surrounding temperature, especially near the worker's head; (vi) not alter...
the composition of the air by products of combustion.

The evil effects of bad lighting and eyestrain are discussed in another article ("Occupational Diseases: Eyes"). There may be recalled here very briefly the influence of lighting on the visual faculties.

Visual acuity, that is to say, the faculty of perceiving the details of objects, varies directly with illumination. It increases very sensibly up to about 40 lux. Visual acuity is estimated by minuteness of the details detected. That is why it is measured by the inverse of the limiting angle subtending which two points can be seen separately. Degrees of visual acuity are determined by varying the illumination.

Study of variations in the rapidity of vision, in terms of illumination, with which the eye notices these same details, also shows that it is advisable to raise illumination beyond 40 lux. Rapidity of vision is in inverse proportion to the time necessary for a given object to become perceptible under a given lighting.

Good lighting also increases rapidity of accommodation and continuity of vision. By accommodation is understood the faculty of adapting the eye to the clear perception of objects situated at different distances. Continuity of vision is the power to distinguish clearly an object in the course of observation of a certain duration. Experience has shown that, for individuals whose vision is defective, intense lighting is even more helpful than for normal eyes (see later).

THE TECHNIQUE OF ILLUMINATION

The Placing of Lights

The placing of lights is one of the most important points in the practice of illumination. It may in fact be said that industrial lighting constitutes the problem of the distribution of lights.

When placing lights it is necessary to bear in mind: the height and the position of the source in relation to the working place; the intervals between the lamps; the degree of contrast between the illumination of the working place and that of other parts of the workshop; the chromatic composition of the light; the power of the source and the size of the lamp; the type of globe and reflector; and also the colour and the coefficient of reflection of machines and materials.

The workplace or the surface of the work should also be considered; it should be horizontal or nearly so. It is known that the angle of incidence for a horizontal surface is reduced to 0° when the light falls vertically. Lights should therefore be placed as high as possible compared with the level of the floor. In any case the light should send its rays so that they reach the working place from the side, or better still, over the shoulders of the workman, if the light is sufficiently high. Where a machine is placed between the light and the workman, the lamp should not be in the field of vision and adjacent lamps lighting the room should not cause the production of confusing shadows.

Lamps hung at a height above 6 m. from the floor can be left without reflectors.

FIG. 2. — Placing of the light source in relation to the eye.

Lighting engineers are nowadays more in favour of general lighting than they were some years ago, both for workshops and large offices, and are opposed to separate lamps. In the same way that custom has reconciled people to central heating, it will also reconcile them to the use of general lighting. But it must not be forgotten that this reaction against local lighting is the result of a bad system of application. As a matter of fact, it is too often forgotten that it is not sufficient merely to possess powerful sources of light; a knowledge of how to place them is also necessary.

Lamps fixed to the ceiling should be suitably spaced and set as high as
possible, at 15-30 cm. from the ceiling. Whenever possible a few strong lamps should be used, rather than many lamps of poor intensity. In this way the advantage is gained of putting them outside the field of vision and of using lamps of greater power. Lamps of 500 watts and more can be suspended, for example, at 5 m.

If in a workshop there are gantry cranes, lamps of 1,000 watts may be placed as high as 10-12 m.

Once the height between the lamp and the working level (and not the ground or the floor) has been determined, the spacing must be regulated; for direct lighting the ratio of space to height should be between 1 to 2, depending on the effect of the installation under consideration; for an installation giving indirect lighting average ratios of 1 to 5 can be generally adopted.

The spacing of lights can also be calculated in the following way: deduct 92 cm. from the height of the ceiling of the room, multiply the result by 1.8, in order to get the optimum spacing, or by 2.4, if it is a question of determining the maximum permissible spacing. In practice, the results are satisfactory when the spacing is not more than twice the figure obtained by deducting 92 cm. from the height of the ceiling. Spacing is greater with the indirect system than with the direct system; hence, in spite of the higher cost of an indirect unit, the total outlay on installation is practically the same for the two systems.

In installing lamps account must be taken of several conditions. Thus, for example, the lamp of choice should be that for which the price per unit of lumen-hour produced is the lowest. The presence in the field of vision of an unprotected light is inadvisable, for it would cause fatigue and even injury to the eye at work. However, it is very difficult to determine the degree of brightness of a light and especially the degree of malaise caused by a dazzled eye.

Brightness depends on several factors: the brilliance of the light, expressed in candles per square centimetre of the luminous area; luminous intensity of the light; its distance; the angle at which the light reaches the eye; and the degree of contrast between the light and its surroundings. Clearly, if all these factors are to be taken into account, any code of rules would become somewhat complicated; meanwhile, in practice a simple test is required which enables the question to be answered as to whether a lighting system is adequate.

In practice, it is considered, after taking account of the protection which the eyebrows and eyelashes afford to the eye, that the brightness of a light is much softened if it is placed relatively high. It has also been suggested that, unless light makes an angle of less than 30° with the horizon, it does not enter the eye directly. It is further estimated that the average brightness of the sky, which is about 25 lux per 61 sq. cm., should be considered as an indication of what brightness the eye can tolerate without injury, and that in no case should lights placed on the line of vision have a brightness above this limit.

**Globes and Reflectors**

The term *globe* is given to any spherical protector made of glass, whatever the type, which completely encloses a luminous source in order to limit its brightness and promote diffusion.

The term *reflector* is given to any apparatus applied to a light, enclosed possibly in a globe, capable of reducing the intensity or of modifying the direction of the rays from the light so as to localise the illumination. As a general rule every light used for localised illumination should be protected when its brightness exceeds 0.75 lux per square centimetre.

The common types of globes are of glass, either frosted, opal, opaline, white or transparent. Experts prefer "holophane" globes, made of small lenses juxtaposed which enlarge the image of the light, soften its brightness more than other globes, diffuse the light very well and only absorb 10 to 15 per cent. They also modify the direction of the rays in the direction desired. Globes combined with reflectors are unexpectedly found.

A special type of globe should be adapted to each type of lamp (cf. British Departmental Committee's Reports).

A *reflector* — a genuine industrial contrivance — localises the light and conceals its source, thus protecting the eyes. It causes diffusion of the illumination and the necessary modification of the polar curve of the light. The luminous field projected by a reflector is proportionate to the depth of the reflector, to the height at which the lamp is placed and to the surface to be illuminated from the source of light. A reflector should completely cover the lamp, should prevent light from striking the eye directly, and should send most of the rays in the right direction. And so it is seen that calculation of the lighting arrange-
ments and choice of adequate reflectors are matters for serious consideration.

For local illumination, a light of about 25 watts and not exceeding 50 watts is advised.

Reflectors may be made of enamelled metal, china or glass. In each particular case fittings, i.e. globes and reflectors, should be chosen which give the best coefficient of use.

Reflectors are also made of polished metal or silvered glass, and are often combined with a demi-globe of the holophane type, which acts as a diffuser for the lower hemisphere.

Of course the nature and reflective power of the walls and ceiling must be taken into account. But above all the rapidity of depreciation must be carefully calculated in order to use only lamps in the best working condition.

**NECESSARY ILLUMINATION**

A practical rule has been proposed that the amount of light necessary for a working place is a quantity such as will enable the workers to distinguish readily the objects on which they are at work at a distance equal to four times the "distinct vision" of each worker.

The natural lighting within any building may be defined as the "quotient of natural light" which, according to Weber, is the difference between the luminous intensity at a working place in a room and that existing at the same time out of doors. This quotient is also a fraction of the daylight which reaches the place in question and varies for different workplaces in the same room. The minimum quotient should not be less than 0.5 per cent.

As regards artificial light, the source should be placed in such a way that the angle of illumination is as great as possible, one of 30° at least according to Weber. In principle illumination should be such that work can be carried out without any effort, even if it is prolonged.

As regards a definition of "good lighting," the second report (1921) of the British Home Office Departmental Committee on the Lighting of Workshops and Factories considers the

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**Fig. 3. — How work at a lathe should be illuminated.** The reflector covers the light source entirely and concentrates the light on the work at the point where it is most required. The worker's eyes are protected against dazzling from the source which is of maximum efficiency. It is also necessary to make sure that the light source is fixed in the best position and one which prevents discomfort to the eye from the dazzling reflection of polished surfaces.
following conditions very important: efficient and reasonably uniform illumination of the workplace, placing or shedding lamps in such a way that the light does not strike directly on the eyes of persons at work or when they look horizontally across the workshop; and the suppression of sharp shadows and of any moving light.

But the first report of this Committee, which appeared in May 1915, did not specify any standard of illumination required to enable a given piece of work to be done efficiently; it merely suggested what should be the standards of lighting necessary for the safety of workers in general. In its third report (1922), however, the Committee drew up a list of processes classified as "fine" (requiring at least 30 lux) and as "very fine" (requiring at least 50 lux). Nevertheless, these standards do not represent the minimum legal standards, but are only suggestions for the minimum necessary in practice, for easy and comfortable work.

A well-marked distinction should be a matter of fact made between legal minimum standards and those recommended; the latter being naturally higher than the former and such as cannot be found in practice in industrial lighting.

Then again these minimum standards are only rarely met with in factory legislation, legislation often laying down standards much lower than those used by employers in modern factories. On the other hand, the codes for industrial lighting prescribed by the United States fix standards for lighting for the different industrial operations. It is significant that in the last codes, three standards of illumination have been fixed, viz.: "a minimum authorised for work"; an illumination "recommended for good work"; and an illumination "recommended for good output"; this last being recommended for factories where the management wishes to ensure a maximum output with the minimum waste.

Broadly, it may be said that for rough work, e.g. forging or in foundries, 20 to 40 lux may be necessary; for work of a semi-fine nature, such as locksmiths, from 40 to 60; for fine work in adjusting, from 60 to 80; for very fine work on machines of great accuracy, from 80 to 100; for reading and writing, at least 30; for drawing, at least 70 to 100.

In the case of work on objects the colour of which is uniform the above-mentioned standards will be required; but for sewing on white, for instance, less will be required than for sewing on dark material, as allowance must be made for the reflecting power of the objects on which the light falls (see later).

According to the French Committee on Lighting the minimum for safety in the least-lighted part of any working place should be from 1 to 5 lux. A minimum at the level of the work is difficult to fix in an absolute manner, for it depends on the surrounding conditions and the nature of the objects worked on; but it should not be less than a hygienic minimum for the eye, that is, 5 lux. A list of minimum illuminations for different categories of work should be fixed, a minimum below which employers are recommended not to fail.

These minimum standards vary in the French list between 10 and 30 lux according to the industries and operations; 50 lux is proposed for weaving dark colours, for room used for dressmaking with dark materials, handling of hides and skins, in testing and verifying small pieces in engineering workshops, and in drawing offices. Even 80 lux is suggested for dressmaking workrooms where black materials are used.

Generally speaking, artificial light is not, at least in medium and large factories, below the physiological requirements of the eye. In conclusion the minimum illumination of workshops may be fixed at 25 and 30 lux for horizontal lighting if the lighting is by diffusion from the ceiling.

With other systems diffusers of large diameter, giving a brightness of about 0 to 2 candles per square centimetre, may be used. For delicate work and in schools an illumination is needed of 30 to 40 lux, and even of 50 lux if the work is of a dull hue and if the light is not diffused from the ceiling. When the work is of a dark colour a general illumination of 10 lux may be required and a separate lamp for each worker as well, fitted with a reflector, producing a brightly lighted circle in which the worker can place his work, surrounded if necessary by black screens. In this way it is possible to have perfect illumination for work, but the localised lighting should not be too intense if the room is dimly lighted.

Rational lighting at the present time is fixed with regard to the cubic space of a room, instead of with regard to the horizontal surface to be lighted.

**The Work**

An important part is played in the problem of illumination by the "work" factor, which is of importance from
such different points of view as size, colour and brightness.

The work should be lighted so as to permit easy working, in other words so that it does not strain the eye. But it is not possible to eliminate shadows entirely, for by so doing there is risk of eliminating the contrasts which are often necessary in judging good work. Shadows should, however, never fall on the lighted parts.

Granted that visual acuity is normal, for fixed work lighting will be adequate if a text in "diamond" type can be read easily in the darkest place, and the coefficient is low, more light must be provided.

If the work itself is of a bright nature, it is helpful to provide a background which is better lighted; but if the work presents a brightness below that of white paper illuminated by 10 lux, an illuminated background will be injurious to the eye. Any white brightness around the work often increases by a third the brightness of the work. If the work and the background are dark, a more powerful artificial light should be used and the workers should be supplied with black gloves to avoid the injurious effect of glare from the hands. On the other hand clothing should be light coloured, the presence of a light-coloured diffuser being useful at this distance.

A large background of brightly lighted white paper around the work greatly increases the visual acuity, if that is good, by about 1 for illumination above 10; but it diminishes it when it falls below 1, which occurs for work that has only little brightness. The same fact is noticed if a source of light with a naked flame is placed in the field of vision.

![Fig. 4. — How work at a lathe should not be illuminated. The lamp is insufficiently protected by reflector and the light strikes the worker's eyes instead of illuminating the work. Hence eyestrain and waste of light.](image)
A very important factor is a bright surface to the work. According to the law of equality of the angles of incidence and reflection, reflected rays reach the eye of the worker, who is thus exposed to rapid fatigue of sight and is no longer able to distinguish the details of his work.

INJURIES CAUSED BY BAD ILLUMINATION

The eye is adapted to sunlight, and it is hard to admit a priori that this light contains elements which are injurious to the organ of sight.

But there are special conditions of work or a particular state of the eyes, which render harmful some elements in sunlight and artificial light and require careful examination. This is dealt with in the article "Occupational Diseases: Eyes".

This article is confined to giving some consideration to accidents and the relation between lighting and their production.

From the point of view of industrial accidents, general, and injuries of the eye in particular, the facts available show the danger of insufficient or badly arranged lighting and the necessity for legal intervention.

The British Committee, already referred to, collected evidence which proves that during the winter months, owing to artificial lighting and the necessity for legal intervention, accidents are more frequently notified.

During the day and in parts insufficient, in 7.8 per cent.; bad in 3.5 per cent.; in parts good in 29.1 per cent.; insufficient in 18.8 per cent.; good in 32 per cent.; middling in 29.1 per cent.; bad in 3.5 per cent.; in parts good and in parts insufficient in 7.8 per cent.

In some departments of a factory the difference between the frequency of accidents which occur by day and those which occur by night is greater than in others. It is probable that this greater frequency of accidents during the night period is associated also with the factor of fatigue, which workers on night shifts experience more readily; but it should be noted that no exhaustive enquiry has yet been made into the subject.

As a result of an enquiry dealing with 466 factories, Fisk was able to show that the lighting was excellent in 8.7 per cent. of works; good in 32 per cent.; middling in 29.1 per cent.; insufficient in 18.8 per cent.; bad in 3.5 per cent.; in parts good and in parts insufficient in 7.8 per cent.

Radermaker studied the lighting arrangements of 390 American factories and found that only 15 per cent. had good lighting, 29 per cent. had average lighting and 56 per cent. bad lighting. At a recent American Congress it was recorded that out of 91,000 industrial accidents 24 per cent. were due directly or indirectly to insufficient or inadequate lighting. More recent statistics give a proportion of 1 accident in 8.

It is estimated that 250 million dollars are spent yearly in the United States on industrial accidents, of which more than 50 per cent. could be avoided. Among these accidents eye lesions claim a percentage of 8.3. As a matter of fact it is calculated that eye accidents number 200,000 yearly, and that 15,000 blind persons owe their misfortune to an accident whilst at work; this represents 13.5 per cent. of the total of the indemnities paid for accidents in general is 13,332,220 dollars.

In a report presented to the Illuminating Engineering Society of the United States, Dimson mentions that according to the Travelers Insurance Company, out of 91,000 accidents notified during the year 1910, 23.8 per cent. were due to imperfect lighting.

In conclusion, some insurance office experts estimate that 25 per cent. of accidents are connected with insufficient lighting; but it should be noted that no exhaustive enquiry has yet been made into the subject.

On the other hand, researches relating to the effects of lighting on visual acuity and the discrimination of details and eye strain have been keenly pursued. With this object in view there has been measured the time required for recognising a black spot on a white ground while varying the luminous intensity. The time diminished 33.3 per cent. when the lighting changed from 30 to 100 lux and 60 per cent. when it changed to 900 lux.

Speed of discrimination showed still greater variations; for the time diminished 37.5 per cent. when the lighting changed from 30 to 60 lux and 67 per cent. when it reached 120 lux. These are rates for normal individuals; astigmatic subjects showed a more considerable diminution.

The effects of lighting on eye strain have been measured by means of a vision test lasting three minutes. Eyestrain during continuous vision causes vision with blurred details. The estimate was established by comparing the time of dazzled vision with the total time, under varying degrees of luminous intensity. The comparisons obtained have been in normal subjects 32 per cent. with 30 lux; 29 with 50 lux; 5 with 120 lux; and in astigmatic subjects 38.32 per cent. and 12 per cent.

The problem of lighting is still more important at the present time, if regarded from the point of view of increasing industrial output. A long series of experiments has shown how much it is to the advantage of manufacturers to light their factories properly; output increases from 10 to 24 per cent., which compensates largely for the expenses of putting in a good system of lighting; work is more accurate and careful; accidents are less numerous; waste is reduced; supervision is easier; the work-
place is cleaner and better kept; the operative works contentedly because he is working under better conditions.

It may be useful to quote some of these experiments.

In analysing simple manual operations, such as are met with in practical industry, W. Ruffer has shown that increase in illumination always leads to increase in output which varies naturally with the kind of operation. This increase is always pronounced as the standard of illumination rises from 25 to 100 lux, and is often considerable when it rises beyond 100 lux.

In 1921-1922 the American Board of Industrial Hygiene undertook some researches of vast scope in a number of post offices, with the object of determining if improvement of lighting in letter-sorting rooms increased the output of 4,800 persons employed there. Those who worked with the old system under poor illumination showed defects of vision more numerous than those who worked under more intense illumination. Rapidly in executing work was greater in proportion as the lighting was more intense. The increase of output was 4.4 per cent. when the average illumination was increased from 36 to 80 lux; the change represents for the Post Office an annual economy of more than 100,000 dollars, after taking into account the expenses of altering the lighting system.

In a workshop for testing pieces of machinery an increase of output with a new scheme of illumination, wherein 130 lux and 200 replaced 50, was respectively 12.5 and 8 per cent. Good lighting then increased the output by 12.5 per cent. for an outlay of less than 2.5 per cent. of the wages.

Finally there need only be quoted the experience of an American employer who has given his results in an article entitled “How We Have Increased Our Output by 25 per cent. by Improved Lighting” (1923), and obtained an increase of 13 per cent. on the output with a lighting of 60 lux, of 17.9 with one of 90, and of 25.8 with a lighting of 140 lux. The increased cost was only 2 per cent. of the wages.

Thus it cannot be denied that the beneficial results of the increase of output exceed by a great deal the cost of improving the lighting. Experts have easily shown that an average increase of output of 15 per cent. can be obtained at the price of an increase in expense equal to 2 per cent. of the wages; that is to say, the work of two men out of a personnel of 100 was sufficiently good to produce as much as 15 of their fellow workmen. Or, if it is preferred, the saving is effected of 8 minutes a day per workman as a consequence of better lighting which reimburses the total cost of the lighting.

The construction of a curve of variations in the expense of lighting used for illumination, shows that it is possible to carry the lighting from 20 to 80 lux by simply multiplying the expenses by three.

LEGISLATION

In order to establish a scheme for illumination the standard of the illumination necessary must be decided first of all; then the system of lighting must be chosen and the installation which is best suited to the place and to the processes which are to be carried on there; the height for hanging must be decided, the spacing and the number of lights required; while the power of the lamps to be used in the installation must also be calculated.

An expert well up in the technique of lighting is able at the same time to give the necessary advice for arranging an installation which satisfies both the requirements of hygiene for the eye and also the technique of lighting.

Propaganda for good lighting and good hygienic conditions for eyesight should be carried out among managers of works and workmen. It has developed of recent years and numerous pamphlets, tracts and posters have been published on the subject.

Without giving here the exact wordings, which are rather long, it may be stated that notices have been drawn up by the Illuminating Engineering Society of London, and that English, German and French posters exist which give the workers advice on the hygiene of vision, and on first-aid in case of accident to the eyes.

The question of making regulations is complex. Legislation was confined at the start to making regulations for the lighting of schools, and even that is not universal. As regards factories and workshops the law is often confined to the
in which the object is to ensure the maximum output with minimum effort. The Standard Code for Industrial Lighting prepared by the American Association of Illuminating Engineers in 1915, after having undergone a first and slight modification in 1918, was reissued in 1921. During these thirteen years the Standard Code was adopted as it stood, or with modifications in detail, by eleven American States. A new edition was published in December 1928 which gives in the first part the objects of the Code, its field of application and the minimum standards for places of work, for yards and passages; for work requiring vision essential for details, for vision less essential, very essential, and non-essential; and for vision for very small details. In the second part information is given on points raised in the first part, as well as the standards to be recommended for certain operations or industries. The third part is devoted to the benefits of good natural or artificial illumination and its economic advantages.

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The illustrations used have been taken from The Protection of Eyesight in Industry (mentioned above).

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(London).
Industrial Physiology


GENERAL REMARKS

Industrial physiology constitutes at the present day one of the most important fundamental facts, if not the essential fundamental fact, of the scientific organisation of industry. Physiology and technique must be studied with a view to ensuring that human energy is used to the best advantage in the service of society, and with the least possible harm to the individual, who should thus furnish a maximum of production with a minimum of fatigue.

With the modern development of industrial machinery, the technique of human activity, whether it be some industrial tradition wholly manual or nearly so, has to be transformed and adapted to the new conditions of production. But the aims of organisation seem to have been limited, until quite recently, to technical problems connected with the construction of machinery and the organisation of business establishments; and, while the great progress of mechanism has caused these problems to be regarded as constituting the primordial element in production, the role of the human factor has been deemed to be of less and less importance, in proportion as the power of motors and mechanical tools has developed.

Although the necessity for studying man's capacity for work has only quite recently been recognised, it must not be forgotten that the physicists of the seventeenth century had actually turned their attention to determining mathematical formulas for maximum activity (La Hire, Amontons, Vauban). Later Coulomb collected the first data dealing with fatigue, by studying the value of, and the comparison between, the consumption of energy by studying respiratory exchanges. Lavoisier was the first to establish the relationship between oxidation in the body and the production of force. Chauveau, as well as other experts, followed this up at the end of last century.

During the war, the necessity for intense and continuous production, invested the physiological problems of industry with an importance which has not yet ceased to increase. Even technical exponents of Taylorism pure and simple realise that the mechanical and technical side of scientific organisation of industry is no longer sufficient. The problem of the organisation of industrial production is recognised to be definitely bound up with the problem of diminishing the functional strain experienced by manual labourers, who govern and control this production.

For this reason certain data which seemed to be definitely established are being revised to-day. Even machines which are looked upon at the present time as having been brought to the highest point of perfection seem to need revision as regards principles of construction in order to be better adapted to the men who tend them, for it is recognised that adequate modification of means of control and of driving-wheels can lessen the fatigue experienced by the men who supervise the starting or running of machinery.

The domain of industrial physiology extends further than the execution of work properly so called (motor or intellectual action), and is concerned with all the immediate or mediate conditions relative to work: the factors of work; the environment; the personal element, both physiological and psychological; and so-called social factors. All these conditions play their part in influencing the organism, and may in some way control aptitude for work, output and fatigue.

The aims of industrial physiology are essentially practical. It must respond to the calls which are made on it by industrial life and must elaborate measures which will ensure the greatest efficiency for the human machine. These ends can only be attained if there exists preliminary knowledge, far-reaching and accurate, of the mechanics of bodily activity. Industrial physiology relies on such solid facts as physiology, pure and simple, has been able to establish; but, in the face of new problems, it is often obliged to adopt for itself theoretical foundations suited to practical exigencies. Thus it is necessary to review the theoretical aspect and the practical aspect of industrial physiology.

THEORETICAL CONSIDERATIONS

The researches carried out up to the present have been concerned chiefly with physical work, for the very sim-
ple reason that our knowledge of this form of activity is relatively more extensive than of the processes which are at the basis of psychical work. And so in what follows there is chiefly in view activities which have for their basis the action of muscular force.

The functioning of the human machine is dependent on its physical structure, on the anatomical and morphological factors of the body, and on the available energy which is supplied by combustion within the body of the hydrogen and carbon contained in food. Part of this energy serves for performing work; the rest is used for maintaining the body temperature. Food is burnt up within the body by the respiratory oxygen, combustion of which is controlled by the rate of the organic processes. Thus by material, or, better, by their true calorific power, which is lower than the heat of combustion, since food is not used up absolutely, depending upon the coefficient of digestibility.

In the human and animal economy muscle is considered as the motor, while power is that of contraction, whether it maintains a load in equilibrium without movement (static effort) or whether it causes movement (dynamic work, movement or resistance).

The researches of Fletcher, Hopkins, Meyerhof, Hill and Embden have made fairly clear what processes lie at the basis of the shortening of muscle fibre.

studying the chemistry of the respiratory gases there is provided a means of observing the extent and variations in these processes. Without going into the problem of food, which will be dealt with separately, it is enough to bear in mind that the energy value of food is measured by the heat of combustion, i.e. by the number of calories developed by the combustion of a gramme of the a matter of fact, physically, there is only work when there is transformation of potential energy into kinetic energy; whereas physiologically even if there is not this transformation of energy, there is consumption of energy. Thus a muscle fixed in contraction does not develop kinetic energy, but is a manifestation of so much work (Allers).

lactic acid, by an unknown mechanism, causes shortening of the contractile elements of muscle; this view is, however, disputed by Embden.

In the second phase which precedes relaxation the lactic acid combines with alkaline proteins. In the final stage a small part of the lactic acid is burnt up, whilst the greater part is used afresh for the synthesis of lactic acidogen.

The thermic activity of muscle is similarly characterised in the three stages by the liberation of heat. The researches of Hill have shown that the quantity of heat given off in the third stage, that is to say, during the oxygenating or rebuilding process (Erho-
Effort by all the muscle fibrils that the yield undergoes no loss. Another source of loss of energy is that muscles which are fixed to parts of the skeleton by their tendons have to overcome the resistance of friction arising from movements of the limbs. The processes of stabilisation and balancing the body involve loss of energy. When lifting weights not only does the requisite group of muscles come into play, but also their antagonistic muscles. Whereas dynamic work requires relatively few muscles to be brought into action, static work brings into play a comparatively greater part of the total musculature, in order to fix and immobilise certain parts of the skeleton so that the body may be placed in the most favourable position for work. Further, balance must be so maintained as to prevent any loss of effort.

This yield must be regarded as theoretical, for it only refers to a fictitious contractile element, wherein there is no loss of energy during the transformation. In reality contraction uses up a certain quantity of energy in overcoming the viscous resistance of the contractile element. Hence results depreciation in the theoretical yield.

Passing now from isolated muscle fibrils to the muscle as a whole, it is found that the theoretical yield undergoes a further depreciation, because some fibrils do not take an active part in the contraction, but are involved passively. It is only in a maximum equilibrium. And lastly, account must be taken of the amount of energy needed to move the weight of the body itself (see also article "Effort").

An important task for industrial physiology is to determine the value of these different sources of loss of energy for different kinds of occupational activity carried on by the human machine. The problem is solved by splitting up the entire yield of the human machine into its separate component parts.

A little reflection shows that the general effect of all isolated activities is the same as that of the total activity. If in a case of poor total yield, the

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**Fig. 7. — Consumption of energy by unit of work whilst moving a small truck on the level.**

**I. Pushing**

(A) By means of a handle fixed at 50 cm. from the ground.

(B) By means of a handle fixed at 100 cm. from the ground.

(C) By means of a handle fixed at 150 cm. from the ground.

(The four diagrams of each group correspond to a load of 10, 12, 14 and 16 kg. respectively.)
The economy of work is to be increased, simple consideration of the facts shows that high component yields do not need to be improved, but that poor ones do. The nature of this splitting of total activity into its elements and the practical consequences are phenomena which have been demonstrated by Atzler, Herbst, Lehmann and Müller in the operations of weight carrying and of working a crank handle.

The discussion so far has not dealt with the influence that training or practice (Ubung) may exert on the value of the total activity. Everyone knows by experience that an act which can only be accomplished with difficulty when there has been no training, can be accomplished more and more easily, and finally become as child's play, as practice gradually increases. Chauveau has shown that output im-

![Image](https://via.placeholder.com/150)

**Fig. 8. — Consumption of energy by work at a crank-handle.**

1. **Light Work**
   (A) Lowest position of wheel.
   (B) Average height of wheel.
   (C) Greatest height of wheel.

   (The three diagrams of each group correspond to a small, average and large diameter of wheel respectively.)

proves with continued work, just as with increased speed and dividing up the load. If the external work done at the same expenditure of energy is compared on successive days of practice, output is found to improve with practice, until finally, when training is complete, it attains a maximum value which thereafter is steadily maintained. The muscle fibre has now become more easily stimulated; the nerve cells and nerve fibres are more excitable; and starting is less onerous. But this economic improvement must be attributed principally to an adequate adaptation of the system of innervation. The difference be-

between a trained subject and one who is not trained is that useless accessory movements are eliminated in the case of the former. His muscles, when taking part in the execution of a premeditated act, contract under the influence of the nervous system in the most favourable succession and with an optimum intensity. The performance of a co-ordinated movement depends upon the fact that the sensory apparatus takes its part as the organ of control and modulation. In addition to this sensory-motor regulation, the deep reflexes, studied by Paul Hoffmann, exert a great influence upon the performance of finely differentiated co-ordination of the movements. If, for example, a sharp increase of tension is caused in a muscle, a contratension is caused on the arc of the deep reflex. In this way inequalities in the sequence of a movement are compensated. These special reflexes, in addition to those of external origin, are invested with the duty of facilitating the precise performance of a premeditated movement.

Reference may here be made to one form of these reflexes of external origin, viz. the reflexes of position, studied by Magnus and his pupils, which are of great importance for the maintenance of position at work. In an untrained subject, all these reflexes are under the control of the higher nerve centres. As training proceeds, the paths of the reflexes become more and more definite with the result that
it becomes impossible for any to leave the path, and movements become more and more automatic. The higher centres are thus freer in their work and can devote themselves to meet all the difficulties connected with that effective modulation of movements admired in trained workers.

With the onset of fatigue the style of movement loses its co-ordinated character, and the work of a trained subject degenerates into the type of work of an untrained subject. Fatigue is characterised manifestly by the fact that certain nervous mechanisms which overlap one with another are no longer functioning correctly. It cannot be yet said, at the present time, how these disorders arise; some speak of exhaustion of energy-carrying material, others of the accumulation of such waste products as acids and toxins which exert an inhibiting function.

While these phenomena may be produced in an isolated muscle, which can be fatigued by a series of stimulations repeated over a long time, the conditions connected with the production of industrial fatigue are essentially much more complicated. The operations of work require the participation of the central nervous system, of the peripheral nerves, the terminations of the motor nerves, and of a series of muscles, and of reflex arcs. It is not possible to analyse beforehand the part played in work by each of these different components. A special complication arises from the intervention of psychic factors, the influence of which on the shape of work curves has been especially studied by Kraepelin and his students. Mere mention may be made of the antagonising influences of fatigue and training, of habit, of stimulants (Anregung), of different kinds of incitements (Antrieb) and inhibitions (Hemmung). The conditions are rather simpler in kinds of work where the higher centres take only a very small part, as for example in monotonous work. In this instance the higher centres only intervene when certain disturbances arise during work, as for example diminution of attention. This relative diminution in complexity of automatic movements enables, as will be shown further on, the problem of industrial fatigue to be grappled with in an experimental manner. These investigations should preferably be extended to those forms of automatic work that are frequently met with, especially in modern factories. It includes movements of small and active muscles, which are limited to a restricted anatomical field, and very active nervous processes which are brought into play for the execution and accurate co-ordination of the necessary movements. Knowledge gained in the sphere of labour shows that these kinds of movements easily lead to manifestations of chronic fatigue and ought to be held responsible for the actual waste of energy.

A series of accessory mechanisms sustain the processes of work, properly so called. Accumulation of carbon dioxide due to muscular activity, as well as diminution in the quantity of oxygen in the area.
surrounding the muscle fibres, render an increase in blood supply necessary. Under the influence of acid products of metabolism, there occurs dilatation of the arteries and capillaries in the muscles at work (Caskell, Atzler, Lehmann, Fleisch); even capillaries, which in a state of rest are closed, become dilated (Krogh). Vascular areas which supply less important organs become constricted, so that an increased blood supply may be directed to parts in an active state. In arduous feats, such as are seen particularly in sport, after the "dead point" has been passed, the vessels of the kidneys and intestines are almost drained of blood. The volumes of the blood stream per heart contraction and per minute show an increase depending on the intensity of the work. If the volume per minute increases more quickly than the peripheral resistances in the arterioles diminish, an increase in arterial pressure is observed, which, in consequence of the increase in the potential pressure, leads to an acceleration of the blood flow. All these processes, which have for their object an increase of the nutritive exchanges in the working muscles, are only crowned with success when the pulmonary respiration is increased. Only so is there possibility of a more active exchange of respiratory gases than during periods of rest. As a result, the same stimulus which acts on the vessels, that is an increase in the oxygen tension of the blood, stimulates the respiratory centre in such a way as to increase the pulmonary aeration.

### Practical Considerations

People in general expect from the human machine as high an output as possible; but they should study the question of maintaining capacity for output at as high a level as possible, without decrease, during many years. These two requirements are in apparent contradiction. If exertion is daily required from a man exceeding the measure of his capacity for output, fatigue products accumulate in his tissues and there cause premature wear and tear. It is the task of industrial physiology to find the golden mean, steering between these two extremes.

The solution of this problem is possible by organising any work which is aimed at, so as to obtain a maximum production with a minimum of effort. Taylor, in the system which is named after him, aims simply and solely at maximum output, without taking into account the consumption of energy by the human machine. In contrast to Taylor's system, the physiology of work seeks optimum output.

Industrial physiology has a threefold duty to perform in order to make the best possible use of man's strength:

1. The right man must be in the right place.
2. The work required of the human machine must be such that it gives a maximum production with a minimum expenditure of energy.
3. Overstrain must be avoided.
In addition to these conditions, a large number of others must be realised in practice in order to obtain a better output in industry and agriculture.

Scientific management presupposes that a correctly organised establishment has at its disposal adequate man power, and that this power is appropriately distributed. Just as technical psychology has worked out a number of tests in order to discover the psychological aptitude of a candidate for a chosen career, in the same way industrial physiology is establishing a whole series of methods which enable either the physical aptitudes of candidates to be determined for work, whether strenuous or not, or the fitness of a subject to be detected for hard work of short duration, rather than for lighter work of long duration.

Selection of workers, carried out by these methods, removes all difficulty from utilising to the best advantage the physical powers of a worker who is fitted for a given task. Thus it lies with industrial physiology to establish for each occupational process conditions under which the human machine functions in the most economical manner.

All industrial and agricultural work can be reduced to a comparatively small number of elementary movements. In this way thirty to forty simple elements are obtained, combinations of which permit all movements, even the most complicated, most favourable conditions are those in which a given external task, say a kilogrammetre, is effected with a minimum expenditure of energy by the body. It is then that the body works at an optimum output.

As regards the human machine there must be distinguished "the industrial or gross output", which is the relation between the energy used and the total static and dynamic energy, from "the net output", which is only concerned with dynamic expenditure alone (Amar).

Accurate determination of net output is rather difficult to make on account of the numerous variations which come into play. The results vary greatly.

There may be mentioned by way of example, the turning of a crank-handle, the lifting of weights, the actions of pulling and pushing by hand, either in a vertical or horizontal direction, and that of pushing or pulling loads or wheelbarrows. Examination of the elementary movements involved enables the optimum conditions necessary for practice to be determined.

The amount of energy expended, as well as the amount of external work done, gives a clear perception of the economics for the type of work under consideration. If the external work, that is mechanical work, is divided by the expenditure of energy expressed in kilogrammetres, the total yield of the human machine for the work in question is obtained. Among the different variations of a factor of work, the

Fig. 11. — Consumption of energy by weight-lifting.

1. Height from which Weight is Lifted: 0 cm.
   (A) Height through which lifted: 50 cm.
   (B) Height through which lifted: 100 cm.
   (C) Height through which lifted: 150 cm.
   (D) Height through which lifted: 200 cm.

(The three diagrams of each group correspond to a weight of 10, 20 and 30 kg. respectively.)
one from another, according to numerous investigations; but generally an average of 25 per cent. is accepted (Amar).

Practically, it is the industrial output of the group of acting muscles which gives the actual output and is alone of interest. It varies from 4 to 10 per cent. according as the quantity of daily work increases, and attains with difficulty 16 per cent. (Amar).

It should be noted at this point that the power exerted by a muscle is a function of its mass, i.e. its active fibres, of its degree of contraction, and of the angle that its direction subtends with that of the bone to be moved. The absolute force of muscles varies, however, according to the muscles considered; but the average force is about 75 grm. per square millimetre of section (Amar). Numerous researches and measures have been made to determine the maximum value of the force, either of pressure or traction, which man can develop with his muscles. For an adult man the average value seems to be 150 kg.; and half that for a woman (Amar). Nevertheless, the exercise of force depends first and foremost on the nature of the work and the number of alternate contractions; further, the maximum rhythm of the contractions varies for different muscles and articulations.

### A Type of Physiological Investigation

A simple example, taken from weight lifting, will illustrate the technique of the researches. The task consists in grasping with both hands a weight which, according to the experiments, is at different heights from the base, in lifting it to a fixed height and then lowering it. By varying the height from the base, and the height to which the weight is lifted, as well as the heaviness of the weight, the following results have been recorded:

#### TABLE I.—Expenditure of Energy in Lifting a Weight Under Different Conditions

<table>
<thead>
<tr>
<th>Height from base in centimetres</th>
<th>Height of lifting in centimetres</th>
<th>Weight in kilograms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9.15</td>
<td>18.95</td>
</tr>
<tr>
<td>0</td>
<td>50</td>
<td>56.78</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>59.30</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>48.31</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>44.47</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>50.69</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>38.08</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>36.15</td>
</tr>
<tr>
<td>100</td>
<td>50</td>
<td>31.87</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>32.40</td>
</tr>
<tr>
<td>150</td>
<td>50</td>
<td>38.31</td>
</tr>
</tbody>
</table>

The heights at which the weights were placed before being raised were 0, 50, 100 and 150 cm. above the ground. Starting from 0 m. the weights, as shown, were lifted to heights of 50, 100, 150 and 200 cm. As the starting heights were further from the ground the maximal heights to which the weights were lifted were naturally lower. The consumption of energy, stated in small calories, is calculated in relation to 1 kgrm. as the unit of external work. The subject under observation works under best conditions when he lifts a weight of 13.85 kg., placed at a height of 1 m. above the ground, to a height of 50 to 100 cm. The figures of the table also indicate that output is worst when the height from the ground is nil, that is to say when the subject is obliged to stoop.

Thus this example shows that by comparatively simple corrections in methods of work it is possible to increase output considerably.

When lifting loads it is not always possible to command optimum conditions of work, which, according to the preceding description, are forthcoming for a healthy man of average height when he has to lift through 50 cm. a weight of 14 kg. placed at a height of 1 m. Therefore, tables from which to calculate must be drawn up, and adapted to the variations of the practical conditions.

The case of having to lift objects for a certain height starting from a definite distance from the floor will recur very often. The worker has moreover the possibility of easing his task by lifting at once a larger or smaller portion of the load. The rationalisation tables should make it clear what load should be chosen given a larger or smaller portion of the load. The figures in italics, which correspond to
optima weights, figures are given in brackets which show, in small calories, the consumption of energy per kilogramme of external work. The smaller is the expenditure of energy, the better do the conditions of work adapt themselves to the human machine.

**TABLE II.—OPTIMUM WEIGHTS**

<table>
<thead>
<tr>
<th>Height from base in centimetres</th>
<th>Height of lifting in centimetres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td>0</td>
<td>39.1 (44.5)</td>
</tr>
<tr>
<td>50</td>
<td>39.9 (37.5)</td>
</tr>
<tr>
<td>100</td>
<td>15.8 (29.7)</td>
</tr>
<tr>
<td>150</td>
<td>5.8 (34.2)</td>
</tr>
</tbody>
</table>

These figures show that the subject under observation works under the best conditions when he lifts a load of 15.8 kg. placed 1 m. from the floor to a height of 50 cm.

In the same way, starting from table I, other tables can be calculated, giving the best height from which to start, as well as the most suitable heights to which to lift.

The lifting of loads represents work which occurs very frequently in practice, in connection with transport, warehousing, and building. Clearly, in an industrial process so important, which is repeated so often, a comparatively small improvement in economy is of great social value. As numerous researches have shown, the "flair" of the individual should never be trusted, for the most favourable conditions of work, especially in complicated operations, can only be ascertained by scientific analysis carried out in the way indicated.

Similar research has been carried out on weight-carrying by Miss Bedale at the request of the Medical Research Council (London). Miss Bedale found that loads should be carried, as far as may be, in such a way that the body is displaced as little as possible from the normal vertical position. Thus, for example, carrying buckets and similar loads with a yoke causes the least displacement of the body; and, as a matter of fact, by studying respiratory exchange this method of carrying loads was shown to be the most economic. On the other hand it is slightly less economic to carry the load as two small sacks, one in each hand, as the body has to resist considerable swaying. Carrying weight on the back in a rucksack or haversack is also much in favour. Although this method, considered simply from the viewpoint of energy, may be considered disadvantageous, it has to be employed whenever the hands are required to be free for other purposes. Carrying loads on the head is not very advisable, for the muscles of the neck have to maintain a very strong balancing movement.

Some recent work done by Prof. E. P. Cathecart, in collaboration with Miss Bedale and other investigators of the Industrial Fatigue Research Board, and Dr. S. G. Overton, Medical Inspector of Factories, has been published by the Medical Research Council.

The investigations dealt with the work of women and the result has demonstrated that the optimum load for continuous carrying is equivalent on an average to 35 per cent. of the body weight. This proportion is somewhat comparative, for the percentage depends in a considerable measure on the way the load is carried. In practice a figure of 40 per cent. of the body weight for continuous carrying is generally accepted and 50 per cent. for occasional carrying, which signifies, when expressed in concrete figures, loads of 45 and 55 pounds respectively.

As regards continuous carrying it seems possible to go up to 50 pounds without fatigue with an extra load of 20 per cent. when it is compact, easily handled and does not embarrass walking or the normal position of the individual.

With reference to adolescents these figures have to be reduced as their bodily resistance is less on account of the period of growth. Thus, for continuous carrying, which is particularly dangerous on account of the malformations it may originate, the figures given by Cathecart and his fellow-workers have distinctly lower values. For young girls of fourteen to sixteen years of age, the maximum weight should not exceed 25 to 30 rounds, and for young girls of sixteen to eighteen years, 40 pounds.

Patrizi, of Bologna, has made investigations on carrying luggage in the hand and on the shoulders with a view to detecting signs of fatigue as soon as they appear. These researches deal chiefly with manifestations found in the circulatory and respiratory systems. This Italian expert prefers this method of proceeding to methods which deal with the muscular system, for the heart and lungs are organs which show, practically instantaneously, the least signs of fatigue. The investigations of Patrizi have shown that unilateral loads cause, in the first place, acceleration of the heart and of respiration, whilst methods of carrying loads with the weight distributed symmetrically on both sides of the body have less effect on the cardiovascular and respiratory manifestations of fatigue. The first investigations undertaken did not reach the limits for mean weights to be fixed. However, it was found that a moderate load of 22 kg., not more than a soldier's pack, when carried firmly on a level road, especially if the load is distributed asymmetrically from the beginning, causes reactions which can be detected in the systems mentioned. Thus it is possible to advance certain general proposals, under which the question of weight carrying needs to be fundamentally re-
considered; they would necessarily lead to a decided diminution in the weights which have hitherto been accepted by tradition and established by an empiricism which may be designated "physiological agnosticism". (See also article "Transport Industry".)

CONCLUSIONS

Speed, in many processes, plays an important part in the problem of economy. Thus, for example, with the crank handle 35 rotations a minute, with a spade 17 to 19 thrusts a minute in shovelling, and with a pick 25 to 30 blows a minute, form the optimum.

In this way systematic study of thirty to forty elementary movements in all directions is necessary. Here is a task which can only be carried out by years of assiduous work.

The three diagrams of each group correspond to tables gradually built up will constitute a sure basis for rationalising all human work. Whatever methods of work may develop in the future, it will always be necessary to grapple with the elementary movements in order to organise rationally methods for highly complicated movements. But it is certain that the technique will be simplified by the rules which science has provided. Among these rules, valuable for general application, may be mentioned the following:

1. The musculature called into play on a piece of work should be exactly related to the mechanical work demanded. For strenuous work, powerful muscles must be called on; for light work, less powerful muscles. Example: a bicycle, driven by the strong muscles of the leg, is more adapted for transport than is the invalid chair, propelled by hand.

2. For prolonged work with the body continually in movement it is necessary to choose muscles presenting a comparatively strong index of inertia.

3. Body movements without exterior effort must be slight. Example: work with a windlass is much more economical than with a lifting jack for performing the same mechanical work.

4. Intermediate movements, on the other hand, must not be completely suppressed, and for a good reason. The musculature, as a matter of fact, rests whilst intermediate movements are being carried out. If the proportion of the movements with no effect on the total work is too small, in consequence of exaggerated effort, the muscles work in an uneconomical manner and become rapidly fatigued.

5. The operations of work must be conducted in such a way that the least possible amount of energy is used up. It is much better to do the same mechanical work with a windlass than with a lifting jack.

6. Rhythm in work should be left without constraint. It is generally much better to work rapidly and to interpose long rest periods than to do the contrary. Air hunger, cardiac palpitation and elevation of the body temperature during work of long duration are, in a healthy individual, danger signals, indicating that rhythm has been too rapid, or effort too great.

7. Consumption of energy in maintaining a posture necessary for work should be reduced to a minimum. Examples: (a) when work is done by the arm or hand, whenever possible it should be done sitting; (b) when the arm has to be
extended for a long time, it should be supported.

8. In repetition work the muscle group concerned should be made at stated intervals to rest by putting into action another group. The blood circulation in this way is activated, and fatigue retarded. During manual work it is recommended to get up from time to time and prepare other material for treatment.

9. Static work, e.g. supporting weights and working in a bent position, must be as far as possible entirely eliminated, for in this condition circulation of blood to the muscles is almost arrested.

10. Loads should be carried in such a way that their centre of gravity is sustained vertically on the supporting surface of the body. Example: small modern handbags are much more suitable for carrying equal weights, than the old kind which were so awkward.

11. Clothing must not interfere with any movement. Clothes which are too heavy entail a useless consumption of energy.

But even if the use of these rules for the simplification of work is a means for retarding in the most natural way the onset of fatigue, it does not exclude a study of fatigue itself. It is far more important to establish the limits to which work, simplified in the way indicated, can be carried out, without incurring danger from premature exhaustion of the workers. This result can only be obtained if success in detecting with extremely delicate methods the first appearances of fatigue is attained. Complicated mechanisms, as has been seen, take part in the performance of a co-ordinated movement, and the onset of fatigue is of great import in disturbing this co-ordination. By motion study and especially by the taking of cyclograms, it is possible to observe, particularly in the case of automatic movements, the decrease of fatigue. In the same way the degree of fatigue from certain elements of typical movements continuously repeated can be determined.

The above are some of the problems which industrial physiology has to solve. But those which present themselves for study are, as is well known, the same problems studied in human physiology, e.g. dietetics, circulation, respiration, nutrition properly so called, related functions and body heat.

All these questions are worth far-reaching analysis, while taking cognisance of factors arising from the exercise of occupations, factors connected with the work itself, with the environment and with the personnel.

Among factors of work may be named the duration and intensity of work, the distribution of the work timetable, rest pauses, overtime, work at night and on Sundays. Among factors relating to the kind of work may be cited manual labour, semi-automatic, mental or physical work, its speed, rhythm, or monotonity. Questions of position at work, whether standing, or sitting, or both alternate-

**Fig. 13. — Consumption of energy by weight-lifting.**

**III. Height from which Weight is Lifted : 100 cm.**
(A) Height through which lifted: 50 cm.
(B) Height through which lifted: 100 cm.

**IV. Height from which Weight is Lifted : 150 cm.**
(C) Height through which lifted: 50 cm.

(Same weights for the three diagrams as in the preceding plates.)
ly, and of adapting machines and tools to the workers, are also of the greatest importance.

The environment of work in its turn, includes physical factors and economic and social factors. Among the first may be mentioned the temperature and humidity of the air; the movement and composition of the atmosphere; ventilation and heating; the cubic space of the workplaces; lighting and illumination; noises and vibrations. Among other factors are included: the maintenance of output; wages which act as stimulants to speed and quality in work; other advantages, financial and otherwise, such as paid holidays; discipline; the spurt, the amount of work to be done; the various problems involved in recruiting staff (see all relative articles as well as "Welfare Work" and "Scientific Management and the Human Factor").

Personal factors are no less important: type of workers, race, sex, age, physical capacity and resistance, and liability to fatigue, as well as pathological factors which being on the border line of disease are difficult to diagnose, but generally constitute the first effects of fatigue.

The study of industrial physiology must also be engaged in in common with psychology, as has been clearly seen from what has been already said.

The social side of industrial physiology must not be forgotten. This is all the more important in that fatigue and exhaustion cease to be individual phenomena and involve the workers collectively. Bodily weakness of the working personnel involves deterioration in the quality of work, and diminution in the quantity, and, in addition, a great number of absences from sickness, diminution in the average duration of life, and collective unrest which disturbs the relations between employers and employed, and, as a consequence, increases social expenses (Tréves).

For many years statistics of insurance societies, as well as official statistics, have emphasised the serious morbidity among certain categories of workers, as compared with the average for the whole population.

Physiology has suggested the best means for putting into effect social prophylaxis; and study of the human machine has enabled physiological laws to be fixed. Full advantage from innovations in time-tables and wages can only be realised, if at the same time capital is invested in technical improvements and in the hygienic organisation of workplaces. Then again, reduction of working hours should be carried out progressively in order to enable workmen to adapt themselves to a new state of things without upsetting the even tenor of their lives. At the same time adequate educational and social institutions should be provided so that they may be able to use their new leisure in the best way.

As regards wages, experience shows that a scale of wages once gained seldom diminishes, except under exceptional conditions. Industries, in which the strong and skilled worker is appreciated, sacrifice, in times of crisis, part of their profits rather than interfere with the fundamental principles which are at the base of their workers' capacity for labour.

Thus industrial physiology teaches far deeper lessons than would appear at first sight. Its field of action is continually increasing. It is proving that psychological, physiological and economic assets are closely interwoven and that if they are well established, with a sufficient margin, they inculcate in the working class an increase of the idea of its own self respect and of the whole of that moral attitude which plays such an important part in the intensity of production, the creative force of which, as Tréves says, is sometimes much more important than capital itself.

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The discharge of industrial waste water into rivers may be instances; it may cause deposits of mud which may make navigation difficult, and is often accompanied by exhalations of nauseating smells, or it may hinder the action of natural purification by the presence of antiseptics, or poison the fish by the toxic substances which it contains; it may in fact render the water of these rivers unusable for all purposes, sometimes over very long stretches. Experience indeed shows every day in an indisputable fashion that the discharge of industrial waste water is the principal factor in the pollution of streams.

The elaboration and the application of laws and orders regulating the discharge of these waste waters are very difficult, as the modifications of these laws and orders, which are everywhere continually required, show; also the policy followed by the responsible authorities varies in different countries.

The factory owner should understand that he has a double duty to fulfill: to avoid the pollution of streams and to carry on industry. Economically, there would not be any difference between them if he considered the treatment of waste water as being part of the work of the factory, and if he dealt with it by the same methods he employs in the manufacturing processes.

The war showed in many cases the waste to which we are accustomed, as much in domestic life as in industry. It is certain that many processes could be carried out more economically and numerous by-products recovered.

Thus water, when it is in abundance, is used without care. Washing is almost everywhere carried on in a routine manner, whereas the chemists knows that small volumes suffice when employed in small quantities often repeated. In this way sometimes a part of the product is allowed to be lost and goes to fill up and pollute the rivers. Sullage water, submitted to purification or simply decanted, can be used over again, sometimes with the advantage that, through the concentration which ensues, it is possible to recover with profit certain compounds and so diminish to a considerable extent the expense of purification.

Before undertaking the study of the treatment of industrial waste water, the process used in the factory should be first examined to ascertain if the products employed have acted usefully and thoroughly, if the yield of the manufactured product is in accordance with the theory, and if all by-products which are usable or for which a use can be envisaged have been extracted. Methods of work will arise from such a study which will sometimes abolish any need for discharging waste water and will almost always diminish the volume and facilitate the treatment.

OBJECTS AND PROCESSES OF TREATMENT

It will be understood that treatment must vary according to the trade and even in a particular trade according to the factories. The ends to be attained are:

(a) retention as complete as possible of solid suspended materials;
(b) suppression of acidity and substances poisonous to human beings and to animal and vegetable life;
(c) reduction to a reasonable strength of alkalinity and organic materials.

The treatment of trade effluents varies according to their composition and the degree of purification which is required and can be carried out by (1) mechanical, (2) chemical, and (3) biological processes.

Industrial Waste Water
(Treatment of)


Mankind in its evolution towards improved conditions of living has transformed the conditions of existence. In order to make work less strenuous and to increase output, man has taxed his ingenuity to construct machinery of ever-increasing power and has been led to concentrate industrial operations into small spaces, whereas formerly they were distributed over vast areas. Certain inconveniences which could be tolerated in home workshops become quite unsuitable in large factories. Further, each industry which is started compels the hygienist to solve a new problem.

The unhealthiness of certain industries has been recognised for quite a long time, and authorities have been compelled to take measures for protecting the population either by assigning certain quarters to these industries or by moving them away from dwellings. In recent years citizens have tended to assign certain parts of towns for industrial quarters more or less separated from other quarters. These measures are not always sufficient, for the carrying on of trades may cause trouble stretching far beyond factory walls.

The discharge of industrial waste water into rivers may be instances; it may cause deposits of mud which may make navigation difficult, and is often accompanied by exhalations of nauseating smells, or it may hinder the action of natural purification by the presence of antiseptics, or poison the fish by the toxic substances which it contains; it may in fact render the water of these rivers unusable for all purposes, sometimes over very long stretches. Experience indeed shows every day in an indisputable fashion that the discharge of industrial waste water is the principal factor in the pollution of streams.

The elaboration and the application of laws and orders regulating the discharge of these waste waters are very difficult, as the modifications of these laws and orders, which are everywhere continually required, show; also the policy followed by the responsible authorities varies in different countries.

The factory owner should understand that he has a double duty to fulfill: to avoid the pollution of streams and to carry on industry. Economically, there would not be any difference between them if he considered the treatment of waste water as being part of the work of the factory, and if he dealt with it by the same methods he employs in the manufacturing processes.

The war showed in many cases the waste to which we are accustomed, as much in domestic life as in industry. It is certain that many processes could be carried out more economically and numerous by-products recovered.

Thus water, when it is in abundance, is used without care. Washing is almost everywhere carried on in a routine manner, whereas the chemists knows that small volumes suffice when employed in small quantities often repeated. In this way sometimes a part of the product is allowed to be lost and goes to fill up and pollute the rivers. Sullage water, submitted to purification or simply decanted, can be used over again, sometimes with the advantage that, through the concentration which ensues, it is possible to recover with profit certain compounds and so diminish to a considerable extent the expense of purification.

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1) Mechanical Treatment

This treatment has for its object the mechanical retention of matter in suspension.

Gratins, strainers and sieves are only used in the trades where animal fibres, such as wool and silk, or vegetable fibres, such as cotton and cellulose for paper, are used.

The tanks for decanting, which are universally employed, are not always suitably constructed. Their shape, proportionate capacity, the arrangement of the flow of the water either horizontally or vertically, and the speed of the flow should be determined and regulated according to the nature of the water under treatment. Very often experience alone can indicate the requirements for the construction of an installation. As a general rule, a series of small tanks, each of which can be put out of action for cleaning, should be preferred to one tank of large dimensions.

The filtration used in the trade processes is often sufficient for the treatment of waste water.

2) Chemical Treatment

Addition of chemicals to trade effluents may be made with the object of changing the reaction of the water. Neutralisation should transform the acids and bases into insensitive salts. This operation almost always causes the desired precipitation. Examples: treatment by lime of acid and ferruginous water from cleaning iron; treatment by acids of alkaline lime, salts of iron, alum, magnesia, and acids.

Chemical precipitation nearly always produces a clarification of the water. The precipitate obtained either from the deposition of the soluble matter or from deposition of added reagents produces a great sticky mass which carries down not only fine solid particles, but also colloidal materials in pseudo-solution.

Even perfect clarification produces nearly always only a partial purification and a great number of compounds cannot be precipitated practically or economically.

Chemical treatment of a trade effluent is a delicate process and the uncertain results often described are due to misunderstanding of the reactions produced or to defective regulating. As in every chemical process, definite combinations are formed which are often very difficult to determine exactly, but to understand which an endeavour should at least be made. It is necessary then to set aside a priori the formulas or general recipes; each case should be studied separately.

It is absolutely necessary to proportion the amount of reagents to the extent of the pollution of the waste water, not only to avoid useless expense, but especially to obtain the best clarification. Experience enables the concentration in hydrogen ions which produces the most complete precipitation to be determined.

In factories where refuse waters of different composition flow from different workshops it is always advisable to mix them, which will probably thus give a comparative homogeneity of composition.

The chemical products employed generally are not numerous: they include lime, salts of iron, alum, magnesia, and acids.

Chemical treatment of waste water presents two difficulties: first, the maintenance always of the most favourable concentration of reagents, owing to changes in composition of the water; and, secondly, ensuring rapid and complete diffusion of the reagent throughout the whole mass of the water to be treated.

3) Biological Treatment

Biological processes are only applicable, and then only within certain limits, to refuse water containing chiefly organic material more or less easily putrescible.

(a) Natural biological purification.

Examination of the area of contamination produced in rivers by the discharge of refuse water has led to the discovery of the phenomena of automatic purification which takes place in that area.

Indeed, it is noted that as one gets further downstream from the point of discharge, the river water, at first muddy and coloured, becomes clearer and of better colour. Compounds indicative of contamination, such as organic ammoniacal material, disappear and become changed, the number of micro-organisms diminishes progressively, and a time arrives, if there has not been a fresh inflow in the interval, when the water regains the appearance and qualities which it had upstream.

These changes are produced by the activity of micro-organisms at the expense of the organic material contained in the refuse water. They are facilitated by dilution which carries dissolved oxygen, and reduces the proportion of compounds able to hinder, or even arrest, biological processes, and by physical reactions which are carried on at their maximum in the activated sludge process, as will be described further on. But they are interfered with by other fermentations which develop in the mud and slime deposited and accumulated in the bed of rivers.

Automatic purification is effective when the organic material in solution and in suspension in the refuse water has been oxidised and transformed into stable material. The principal factor is oxygen. The dilution is proportionate to the strength of oxygen in water of the river and the quantity of oxygen necessary for the oxidation of the organic material in the polluted water. Every arrangement which aids re-oxygenation of the river water, such as rapid current, rapids and falls, allows for a diminution in the contamination. On the contrary, it must be considered as harmful for discharges into the sea where the biological action is much slower than in fresh water.
(b) Purification by the soil. — Refuse water can be purified by soil by means of two methods: filtration and distribution or irrigation.

Filtration, especially widespread in the United States where it has been particularly well studied, requires a suitable sandy soil. Sedimentation and irrigation are only practicable upon soil sufficiently porous to allow the oxygen of the air to penetrate at the same time as the water infiltrates. Distribution alone is used by trades depending on seasons, cultural irrigation being too difficult to regulate.

Purification by soil is very efficacious when the land is suitable and of sufficient size and when it can be carried out with care.

(c) Artificial biological purification. — The study of natural biological purification of refuse water in rivers and in soil has led to the invention of methods for intensifying the changes which are produced.

One of the chief difficulties met with in natural biological purification is the presence of solid matter suspended in the waste water. This slime is deposited on the bed of the river or on the surface of the ground, of which it raises the level and subsequently fermenting gives rise to objectionable effluvia and to an unsuitable medium for the oxidation of organic matter.

Simple decanting allows the retention of the water part of this matter, but the slime is not long before it produces serious trouble. In order to reduce the volume and consequently to facilitate the manipulation, fermentation is carried out in tanks of various designs, septic tanks, hydrolitic tanks, Imhoff tanks, etc., either with the liquid part which separates out, or without it.

In all artificial processes of biological purification at a certain stage the separation of the solid matter is indispensable by simple decantation or by fermentation.

Purification properly so called has for a long time been effected upon artificial ground, called bacteria beds because microorganisms play the principal part, composed of materials which present as large a surface as possible, such as slag, clinker or puzzolana. These bacteria beds ought not to act as mechanical filters. The water to be purified, freed as completely as possible from solid matter in suspension, is slowly spread in a very thin layer over the surface of the materials and freely exposed to the air. The colloidal matter in the water becomes fixed on the materials and oxidised, and a residue similar to humus becomes detached at intervals; the carbonaceous matter is decomposed into carbonic acid and water, the nitrogenous matter is reduced and then oxidised into nitrates and nitrites. When the beds are well established and their working is properly regulated, a well-purified effluent results.

(d) In the last ten years a new process based upon another principle has come into vogue. Just as in the bacteria beds an attempt is made to reproduce the best condition of a good soil, so in the process of activated sludge phenomena are reproduced which are found in a strongly flowing muddy river. In bacteria beds the liquid, exposed to the air, flows over the surface of materials crowded with microorganisms; activated sludge, on the contrary, a veritable nest of bacteria circulates in the liquid, impelled by an air current or by mechanical means which allow for the absorption of air. At the end of a period of time varying with the composition of the water the same changes occur as in bacteria beds: the colloidal matter is absorbed by the mud, the organic matter is decomposed into carbonic acid and water, or reduced and then oxidised into nitrates and nitrates, and the water, when separated by decanting from the mud, is purified.

Things do not always occur as simply as has been just briefly described, and most careful trials should always be made before deciding to adopt any process or modified process.

Control of Purification

The most careful investigations for determining the conditions which effluents from works should fulfil after their purification have been made in England. In 1915 a Royal Commission proposed that, according to present-day possibilities, effluents should be tested in two ways:

(a) By determining the amount of solid matter in suspension and the proportion of dissolved oxygen taken up from an aerated water with which the effluent is mixed. In order to fix a limit to the test, the estimation is made after five days. The Commission found that for a certain number of waste waters such a purification could be obtained that the effluent contained no more than 40 to 60 mg. of matter in suspension per litre and did not absorb more than 20 to 40 mg. of dissolved oxygen in five days. These standards, adopted in the United States in principle, may be retained, at least provisionally, as being the least arbitrary. In addition search should be undertaken for substances poisonous to living things, both animal and vegetable.

(b) The more simple test of putrescence is often considered sufficient; this consists in observing if the effluent, kept at 30° C, in a corked flask, gives off an offensive odour after a more or less prolonged period.

Aims and Processes in Treating Waste Water from Various Trades

I. — Trades connected with the Preparation of Food

The presentation, preparation and preservation of foods involve a certain amount of manipulation, during which
waste water is produced. This water, which is more or less loaded with organic matter, purifies very rapidly and then gives off nauseating smells. Such refuse water should be discharged as soon as possible into the sewer or purified.

The food trades include: slaughter-houses and annexes, factories for preserving meat or vegetables, glue and gelatine works, and also dairies.

Slaughter-houses.—Refuse water from slaughter-houses contains blood, urine and some of the contents of the digestive tract from animals killed, and the liquid which flows from the stalls and cattle sheds where the animals wait. Sometimes refuse water from adjoining workshops is added: from gut-scraping, scalding houses and tripe shops. The factories for preserving meat may be considered from the same point of view as slaughter-houses. The concentration of this water depends chiefly on the amount of water employed during slaughtering and preparation and when cleaning down the slaughter-houses; it is in consequence very variable.

Recommendations are always made for the water to be purified or for it to be discharged in the crude state, and for avoidance of solid matter, debris of food, fat, etc., which may be washed away in it; all these have a value by no means negligible. Good organisation provides for the gathering up of these materials into suitable places and their removal at definite times.

There are few waste waters which can be more easily purified by biological processes than the waste water of abattoirs.

Good results have been obtained either by land irrigation or by septic tanks and bacteria beds, also by activating sludge, but it depends on the concentration of the water not being too high.

For very small abattoirs or special slaughter-houses which are only used a few times a week, the rule is to clear the water by the addition of a chemical reagent, such as ferric sulphate, and to purify the clear fluid if it cannot be discharged directly into a river, by distribution or by percolating bacteria beds.

The treatment of waste water from gut-scraping, glue and gelatine works should include the same chemical precipitation and purification on bacteria beds.

Waste water from margarine works contains quite large quantities of fatty material which it is an advantage to retain by decantation following chemical precipitation. The deposit is defatted directly after drying or treated by an acid to extract the fatty acids.

Preserving of vegetables.—The characteristic of waste water from this class of work lies in its acidity, which increases with time. The treatment which has furnished the best results consists in the following processes: neutralisation by milk of lime, decanting as rapidly as possible to avoid the water becoming acid again, and purification by percolating bacteria beds at a slow rate. The deposit should preferably be buried fresh in the ground, or dried upon beds of clinker to be removed after the season.

Milk trade.—This trade, which is well developed, contains a certain number of branches, of which several are often combined: collecting stations, creameries, dairies, cheese factories, factories for casein, lactose and lactic acid.

It is of the highest importance, as much from the economic point of view as from the hygienic, to avoid all loss of by-products in this industry. It is a sad fact that certain dairies still throw away not only whey, but even skimmed milk, at least from time to time. There should only escape from dairies water from washing butter and cleansing the apparatus and the dairy. This water has the composition of a very dilute milk with the addition often of a little carbonate of soda. It becomes acid and putrifies very quickly, so that it ought to be evacuated and purified as soon as possible.

Precipitation by well-chosen chemical reagents clears the water sufficiently, so that in certain cases it can be discharged after this treatment into rivers.

The biological process can only give complete purification provided there is a preliminary treatment for removing fatty materials from the waste water, as that oxidises with difficulty and rapidly forms a deposit on the bacteria beds or on the soil, or checks the action of the activated sludge.

II. — Chemical Industries

In most of these industries materials of known composition are used and well-established reactions are employed. It is also very important not to lose either the materials worked up or the products obtained.

The treatment of waste water, simple as it seems at first sight, presents sometimes practical difficulties. The principle of this treatment is to render
the waste water neutral, so that it does not contain a salt the base of which may cause precipitation when mixed with the water of a river, and does not contain poisonous salts, such as sulphides, compounds of arsenic, lead, or phenol derivatives.

III. — Leather Trade

There is scarcely a trade in which the manufactured products, and in consequence the methods of work, are more varied. However, the necessary processes are the following: reviving, removal of hair or wool, washing with or without deliming, tanning by vegetable or mineral substances, sometimes more varied. All these operations produce waste water more or less strongly charged with organic matter and chemical products, of which the volume varies according to the day and even according to the hour of work. It follows then that the purification of refuse water from a tannery is an extremely difficult problem to solve. However, though results as perfect as those obtainable with other trade effluents are not to be expected, purification can be obtained sufficient to prevent the effluent, when discharged into a river of steady flow, from causing destruction of the fish or any nuisance to the riverside residents.

In order to attain the desired object it is necessary first to endeavour to obtain a water of average composition. The methods of work, in consequence of the building of large factories, keep changing, but by an ingenious combination of renewing the baths more frequently, or suitably regulating them, it seems that, by collecting in a tank of sufficient capacity, a mixture can be obtained as constant as possible of the waste waters from the various workshops. This mixture should afford the advantage of producing by the mutual reaction of all the products a commencement of the purifying process after the first decanting.

This preliminary phase ought to be first carried out whatever may be the final destination of the waste water, whether it is to flow directly into a sewer or to undergo purification. In this last case the decanted mixture ought to be slightly alkaline, which can always be ensured by adding, if necessary, lime washings from lime baths or even additional lime. The addition of a salt of alumina, or a ferric salt, will now produce an abundant precipitate.

Waste water so clarified can, whatever its concentration, be purified by land irrigation. But one cannot here compare the treatment of this waste water with the surface required for the irrigation of liquid sewage; the surfaces ought to be much more extensive and the points of discharge of the effluent upon the land further apart.

When the waste water is not very concentrated or when irrigation land cannot be obtained, the water after dilution may be treated by biological methods by percolation on bacteria beds. Experience will indicate the volume to treat per square metre of surface each day.

Special mention ought to be made of waste water containing arsenic, which must be eliminated by treatment with a salt of iron, or by filtering through waste iron or compounds containing this metal.

IV. — Grain and Starchy Materials Industries

Fecula factories. — The waste water from fecula factories is of two kinds: the water from washing potatoes and the water from washing fecula and pulp. Only the first kind can be discharged after simple decanting. The water used in washing fecula and pulp contains all the elements of the juice of the potato, that is to say, relatively important proportions of nitrogen and potassium which should be made use of. It would be advantageous for the process invented by A. Ch. Girard to be given the test of a trade experiment for the production of manure of commercial value.

A good partial purification can be obtained by treating these waste waters with a chemical reagent, such as ferric sulphate, which produces clarifying by precipitating an appreciable proportion of organic matter.

Suitably diluted with the water from washing the roots, and of course decanted, this refuse water is easily purified directly upon percolating bacteria beds.

Starch works. — The processes of extracting starch are based on the separation of gluten by mechanical action (for wheat), or by dissolving or disintegrating gluten by various chemical products, such as soda and sulphuric, sulphurous or hydrochloric acids, or hypochlorites (for all other grains and roots)

The chemical processes most employed thus produce starch, grain and waste water.

This waste water, including the highly-charged water from steeping
and that from washing, is rich in organic matter and easily putrified.

Chemical treatment, i.e. precipitation by an iron salt after slight alkalinising with lime, gives appreciable results, which may be sufficient when dilution of the effluent going into a river is important.

Purification can be obtained by percolating bacteria beds, provided the water does not contain grains in suspension.

Malt-houses and breweries. — These two trades are often combined; they discharge, as waste, liquor from soaking grain for malting, liquor from draining of the malt, and refuse water from washing receptacles, such as bottles or barrels, and the apparatus and workplaces.

These effluents contain principally hydrocarbons and not much nitrogenous matter; they become acid more or less rapidly according to the season and very soon set free foul smells.

When circumstances require the waste water to be purified, it is always an advantage to have separate outflows for waste water and water (as from refrigeration) not requiring purification.

Chemical precipitation carefully done can give in certain cases valuable results which may be sufficient when it is only desired to discharge a small volume of water into a river the flow of which is relatively considerable.

Purification by distribution, although complicated, can be carried out after neutralisation and decantation of the waste water if suitable land surfaces are available.

Artificial biological processes enable effluents sufficiently pure to be obtained, especially by the use of percolating beds.

Distillation of starchy materials. — The waste from the distillation of starchy materials ought to be treated in such a manner as to render it fit for use.

Brewers' grain should be delivered with the vinasse, or separated for feeding animals. It should be pressed and then dried, so as to be fit to send away when the local demand is not sufficient. If, on account of the process, it is not considered edible, it can be used as manure.

The vinasse, except that upon which acid has been used — as a matter of fact this is rare now — has a great food value. It would be desirable to see a concentration process brought to perfection so that it might be mixed with brewers' grain for use in feeding animals.

When the vinasse is not used it is recommended to treat it by chemical reagents before mixing it with other waste water.

Purification of the whole of the waste water, with or without the vinasse may be obtained:

(a) By irrigation, especially over meadow land, upon a suitable soil, after neutralisation and the most thorough decanting possible; the quantity varies with the composition of the soil and the concentration of the effluent.

(b) By biological processes; the waste water, having been neutralised and thoroughly decanted, can in a suitable dilution be purified on percolating bacteria beds.

V. — Metal Trades

Metal trades include factories of the greatest variety; they can be divided into the following two classes from the point of view of trade effluents:

(1) Iron-works, foundries, etc., the refuse water from which, comparable to that from mines, is charged particularly with matter in suspension, sand, refuse of mineral ores and coke. It is sufficient to decant it through a series of tanks suitably arranged according to requirements.

(2) Works in which cleaning or scouring of metals, or alloys with acids is carried on. It seems to be less costly to treat the liquor of the first and second steepings for the recovery of iron and steel, together or separately, than to neutralise these waste waters before discharging them into a river, as it is indispensable they should be discharged. As this neutralisation should be done by washing water, an attempt should be made to reduce as much as possible the volume of water employed to this end.

When the refuse water contains copper, this metal can be displaced by iron when ferruginous acid water is obtained.

VI. — Mining Industries

In working coal mines waste water from three different sources has to be discharged:

(1) Saline water, containing more or less large amounts of chlorides, alkaline sulphates, and alkaline earth. It is only possible to decant the sand, clay and calcareous substances which it contains. There is no practical way of eliminating the salts; dilution is the
only method of rendering the effluent fit for discharge.

(2) **Acid ferruginous water**, charged with the products of the oxidation of iron pyrites. Its discharge into rivers renders the water not only unusable, for it damages more or less rapidly reservoirs, pumps and conduits, but the damage it causes extends to the destruction of quays and boats. The only process of treatment which appears actually practical is neutralisation of the waste water by barium hydrate; the sulphate of barium which is then formed has a market value which makes up for the cost.

(3) **Waste water** from washing coal which holds in solution saline matter and in suspension coal dust; an effort to remove the latter is made by thoroughly decanting.

The waste water from the working of metalliferous mines contains salts as well as particles of ore which, more or less soluble under certain conditions, cannot be poisonous, being present in very small quantities. Further, certain ores are embedded in silicious rocks which have to be pulverised. The particles of this rock, which are very light and sharp, are removed by the current of water used in washing and may do serious damage to fish.

In the waste water from silver mines are also found sulphates of iron and zinc; in that from copper mines soluble salts of this metal; in that from tin mines sulphides of arsenic or antimony; in that from iron ore mines, sulphuric acid and salts of iron; in that from lead and zinc mines, solid matter containing lead and sulphate of zinc.

In every case the decanting should be as perfect as possible, the metal salts ought to be decomposed and the oxides retained.

Rational use of combustible minerals should be preceded by the separation of products which they contain into gases, volatile products such as ammonia, benzol and tar, and coke. In certain industries where coal is used in its natural state, e.g. blast furnaces, arrangements have been adopted for the treatment of the waste gases. But these operations produce more often than not waste water, although certain processes have not this drawback.

These waste waters are charged with a large quantity of materials which are poisonous to fish and prejudicial, when in certain proportions, to the effective working of biological purification installations. When discharged into a river they often render impossible sterilisation by chlorine of water taken from the river on account of the smell and taste which develop.

A method of purification which will produce at a reasonable cost an effluent which can be discharged without danger into a water course is not yet known. However, the danger can be diminished either by treatment by means of lime and ferrous sulphate, or other reagents, or by bacterial oxidation on percolating beds. The large pit heaps which are found at collieries can be usefully employed for this work, i.e. for making percolating beds. Finally, recourse may be had to evaporation.

VII. — **Paper and Cardboard Industry**

This industry consists in making cellulose pulp which is then manufactured into the greatest diversity of shapes according to the use for which it is intended.

The making of cellulose from wood pulp produces waste water so heavily charged that it is necessary to dilute it with several thousand times its own volume of clean water in order to avoid too strong pollution. For this reason it is recommended that the factories be built by the sea or large estuaries. As a matter of fact no practical satisfactory means of purifying this waste water is known. It has been proposed to make use of it by means of very various processes.

Cellulose from textiles and esparto-grass, which is of the highest quality, is most often prepared with soda, which is worth recovering by evaporation and calcination of the lyes.

The lye-wash from the preparation of cellulose from straw is also highly charged; it can be purified after being mixed with all the waste water from the factory. It is decanted into large tanks and then distributed on percolating bacteria beds.

The majority of paper works prepare little or no pulp; most often they are content to bleach it and treat it, according to requirements, with colouring materials, size and filling.

Attention may here be drawn to two principal points in the purification of these waste waters; first, diminution in the volume of the water used in washing, and then retention by all possible means of fibres carried away by the washing. If these two precautions are carried out, purification may sometimes be unnecessary and may often be obtained by using percolating bacteria beds fed to a comparatively high degree.
The waste water from the manufacture of cardboard is generally distinguished by a unusual proportion of solid material. That from factories making the highest qualities can be treated in the same way as that from paper works. That from the making of inferior qualities, after suitable dilution, may be treated either like waste water from the making of cellulose from straw, or distributed after chemical clarification or at least neutralisation by free lime.

VIII. — Sugar Industry

Sugar refineries. — The waste waters from sugar refineries are of three kinds:

(1) Hot water only requiring to be cooled, which should be done by keeping this water separate from other waste water, when it can be used again.

(2) Muddy water from the transport and washing of beetroot. It is only comparatively slightly contaminated. Suitable decantation in a series of quite small tanks will produce an effluent which can be discharged, usually without causing trouble, into a water-course of average size, provided that it does not mix with fermentable water. Advantage may be gained in case of frequent re-use by treating with chemical reagents such as lime and ferric sulphate.

(3) Fermentable waste water. It is the most dangerous from the fact that it ferments. Three means of purification are open to the manufacturer: natural biological purification, artificial biological purification, and lastly chemical purification.

Natural biological purification by suitable distribution upon cultivated ground is the method most recommended, but local circumstances often prevent recourse to this method.

Artificial biological purification, when carried out with a good knowledge of the method, furnishes very satisfactory results. Trials, not very successful because indispensable conditions have not been complied with, should not a priori cause the method to be abandoned.

Chemical purification, however, if it is borne in mind that there is left in the effluent sugar which is fermentable, can in certain cases give satisfactory results. The water can also be used over again. It is necessary always to bear in mind that the dose of the reagent must be in proportion to the quantity of material to be precipitated, and that it should be neither below nor above what has been ascertained by trial. This implies constant testing in order to vary the charge according to the composition of the waste water.

Beet-sugar distilleries. — Although fermentable waste water may sometimes be negligible in amount, distilleries of beet-sugar should discharge the same effluent as sugar refineries, to which vinasse, the residue of the distillation, is added.

This vinasse contains very important fertilising elements, and an endeavour should be made to utilise them. The best method is suitable irrigation of land. It is always preferable to diminish or even to arrest the acidity of vinasse either by dilution or by fermentation.

When circumstances do not permit irrigation under normal conditions, different methods which have been proposed may be considered. Concentration and the process described by Muntz and Lainé (culture of moulds) should receive attention and deserve practical industrial trials. Artificial biological purification of diluted and fermented vinasse can give satisfactory results.

IX. — Textile Industries

The composition of the waste water in the textile industries varies considerably according to the raw material employed.

Vegetable textiles furnish waste water more or less charged with carbon products, but with very little nitrogenous material. Animal textiles, on the contrary, furnish waste water very rich in nitrogenous compounds, and, in the case of wool, considerable amounts of fatty matter.

Waste water from soaking flax can be purified by natural or artificial biological processes after having been decanted and neutralised. Chemical treatment, although imperfect, will be sufficient in certain cases.

Cotton, either raw or already finished, whether in the form of thread, cloth or waste, must be deprived of all matter which impregnates it so that it can be bleached. The lyes after the boiling down process are very injurious when discharged into rivers. It is necessary to treat them first by neutralising the free alkalis and then to eliminate the greatest part of the organic matter which they contain. Soda or its carbonate are recommended for use in place of lime, for it is possible to recover them and at the same time to
get rid of the most polluting portion of the waste water from this industry.

If all these waste waters are mixed the lyes must be discharged with the other unpolluted waste water so as to dilute them as equally as possible. The inter-reactions produce a certain precipitation which will be increased by ferric sulphate or iron-alum. The effluent thus clarified can be purified on percolating bacteria beds.

Raw wool is charged with an average of 60 per cent. of impurities, of which certain have a commercial value — the fats and potash.

A very great number of processes of purification of the waste water from the combing of wool have been recommended. That most employed is the separation of fatty acids by acidification of the lyes by a mineral acid, either sulphuric or hydrochloric. Precipitation and, at the same time, clarification of the waste water can be carried out by proper addition of a ferric salt; the fatty acids are then extracted from the precipitate. In certain factories the waste water from degreasing is treated separately, evaporated and the residue calcined in order to extract the potash.

Efforts have also been made to concentrate the waste water and to centrifuge it, so as to separate the particles of earth, the fats and the potash liquors.

A recent washing process based on a very simple principle, the process of E. Duhamel, of Roubaix, promises to be very advantageous for the manufacturer and to cause but little waste water.

The mixing of waste water from washing wool with the sewage water of a town causes purification of the sewage to be very difficult. So it is best to treat the waste water at the factory, or at least before it mixes with sewage water. This practice renders purification easier and more economical.

The waste water from scouring silk is also saponaceous, which enables it to be treated by adopting the processes of purification used for waste water from washing wool.

The making of artificial textiles produces waste water the composition of which is easy to discover and the dangerous substances of which can be neutralised with certainty.

The waste water from dyeing and printing thread and cloth contains variable amounts, and sometimes very considerable amounts, of organic and mineral compounds, which may even be poisonous for fish. Since the refuse waters from the various workshops have different reactions, it is recommended to collect them all in a tank of sufficient capacity. After having been neutralised, if required, the water is decanted and clarified by a chemical reagent. The effluent can be purified on percolating bacteria beds.

**LEGISLATION**

The laws laid down for the protection of the health and safety of workers, as well as those laid down for the protection of public health, provide the necessary measures for the treatment and discharge of waste waters.

Each factory should take the precautions necessary for preventing the diffusion of smells and disagreeable emanations from waste waters (see article "Odours").

The factory should construct drains, cisterns, tanks and pipes for the discharge of waste water, of impermeable materials, and should ensure that all joints, etc., are perfectly watertight so that the waste water does not contaminate underground water or the soil.

If waste water is discharged into a public or private sewer, it is necessary to interpose at the point of discharge an hydraulic interrupter which must be cleaned frequently.

Discharging of waste water into a water course or its distribution on land should be prohibited until after it has been submitted to sufficient purification to ensure it being harmless.

Hot water from boilers, etc., should not be discharged until it has been sufficiently cooled.

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Prof. E. Rolants (Lille).
Infectious Diseases


INTRODUCTION

Infectious and parasitic diseases may affect anyone, without distinction of age, sex or occupation. If only conditions favourable for infection exist. These diseases in general constitute, as it were, a generic risk which may be contrasted with the specific risk connected with certain infectious or parasitic diseases, where, in the case of special occupational processes and the disease in question, a connection may be established between the sickness and the work — a close connection resembling in every way that which exists between a lesion due to an occupational accident and the mechanical trauma which causes the lesion.

This specific risk is inherent, either to the occupation concerned, or to the kind of material under manipulation, or yet to the technique, or even to the environment. By way of example, there may be mentioned as belonging to this particular group of diseases, anthrax among tanners, and angstomiasis among miners and brick makers, for which, according to Borri, the specificity of the etiological connection between the work in question and the pathogenic agent must be admitted. And it is on this ground that such affections as actinomycosis, anthrax, malaria, rabies, extra-genital syphilis, glanders and tetanus require to be dealt with separately. An infectious disease should be considered as occupational whenever a right to compensation whenever the disease is contracted, or in consequence of, work. Hence there are conditions of place, time and work, which create the right to compensation, and confer on the disease concerned the medico-legal aspect of an accident.

Indeed, between a generic risk and a special risk, which may characterise an infection according to circumstances, there is an undefined zone, the boundaries of which are very difficult to indicate. With this reservation, it cannot be denied that, in the case of a person working in a hospital or laboratory contracting an infectious disease, or in the case of a workman exposed by the nature of his work to insect bites which transmit pathogenic germs, maybe of plague, yellow fever or malaria, the disease is contracted in a similar manner to an occupational accident. In any particular case the disease acquires a character which enables a claim for compensation to be made.

Experience has also shown that, when similar cases occur, such as plague among dockers, anthrax among tanners, or glanders among stable boys and veterinary surgeons, in the absence of any provisions concerning them in the texts of the laws regulating industrial accident insurance, in some countries, like Italy and Germany, medical assessors have compelled the magistrates to accept the principle that an infection which was produced during work should be considered as an industrial accident. The cyt-o-microbial struggle which occurs in the body as soon as a pathogenic agent has entered it through minute breaks in the continuity of the skin or mucous membranes, and the disorders this struggle causes in the tissues, have been considered by these experts as analogous to a traumatism with its sequelae; thanks to this very broad interpretation of one of the elements in the definition of an accident, a right to compensation has been successfully established. (See also the article "Occupational Diseases: Definition and Compensation").

Without entering into fuller details, there shall merely be enumerated below those infectious diseases which have been reported in various countries as having been, in some cases, considered as occupational in origin. A very brief summary only is given here, the reader being referred to fuller details to treatises on special pathology.

Akamushi disease. — This affection, which is still called "tsutsugamushi disease" or "Kaneda's disease," is a specific affection of agricultural labourers of Japan between July and October at the time of the floods. The disease is transmitted by an acarus (Akamushi). It is very much dreaded by the inhabitants, and when it rages only the poorest labourers will take the risk of exposing themselves in the flooded fields where it is contracted. Clinically the affection presents the appearance of typhus with a duration of one to three weeks; the mortality varies from 25 to 30 per cent.

Aspergillosis. — From time to time English weavers of cotton cloth suffer from epidemics of sharp febrile attacks, associated with a persistent asthmatic cough. Thick sputum, night sweats and loss of sleep at first may suggest tuberculosis; but absence from work brings complete recovery. Mallis, who in 1913 first described two outbreaks, pointed out that conditions favourable to the development of mildew on damp warp threads are present whenever the illness occurs. He ascribed the disease to infectious mildew spores, thrown into the air as the threads are woven on the loom; but the
exact mould concerned has not yet been isolated.

**Bacillus abortus. —** See “Mediterranean fever”.

**Bilharzia. —** According to recent researches, three distinct forms of bilharzia are now accepted: vesical bilharzia due to *Schistosoma (Dichotoma) Haematobia*, intestinal bilharzia due to *Schistosoma Mansoni*, and arterio-venous bilharzia due to *Schistosoma Japonica* (Katayama disease). Bilharzia occurs in the majority of cases through the skin, the parasite penetrating into the system in the form of cercarian larvae, after having passed through an intermediate host.

The disease, which is very common in warm climates, is spread by contact with dirty water, or by the excreta of persons suffering from bilharzia; it attacks Egyptian fellahs and women who obtain their water from “birkets” or pools situated near all the villages, and also workers on low-lying and marshy regions, or on rice fields, especially in Japan. (See also article “Occupational Diseases: Urogenital System”.)

**Blastomycoses.** — This designation covers illnesses caused by certain fungi which for a short period of their existence occur in the exclusive form of budding elements (Villemin). The state of knowledge at the present time concerning moulds does not permit any better classification of the various known fungi (Hammond).

The first case of human blastomycosis was described by Troisier and Achaile in 1893. Gilchrist in 1894 reported the first case of the cutaneous form. Since then observations have increased, and the blastomycoses known at the present time are grouped under the headings of “American blastomycoses”, which seem to be oidiomycoses, and blastomycoses properly so-called which are saccaromycoses.

The agent which causes the first appears always to be a parasite of the genus *Cryptococcus*. This form of blastomycosis is fairly common in America, where it attacks by preference men employed on agricultural work and in handling grain (Montgomery and Rickelit, 1901). Newton Evans in 1903 reported the case of a doctor who inoculated himself with the disease during an autopsy.

The affection is localised by preference on the skin and the lungs.

In 1924 Carter met with three cases of dermatitis, two of which followed directly on traumatism. He thinks that it is necessary to take account of this etiology in cases of dermatitis of occupational or traumatic origin.

Ravogli considers blastomycotic dermatitis as an occupational disease, due to handling animal products or to contact with animals affected with blastomycosis. Ravogli has collected several interesting cases, including two stable boys, a goat breeder, a shoemaker and a slaughterer.

In its chronic form the disease consists of an inflammatory process with an abundant production of spores and the formation of small cutaneous abscesses, with a tendency to ulceration and the formation of granulations. For a long time the lesion was regarded as cancer of the skin or as a warty tuberculosis. The condition occurs principally on the hands, face, limbs and scrotum.

The diagnosis is easy by microscopical investigation for the fungal elements. The development is slow, with a tendency to chronicity and to serious affections of the skin. After a cure, which is sometimes spontaneous, deep scars are left on the affected parts. Chronic cases, in which the viscera are involved, are less contagious than those affecting the skin.

In addition to direct contact it appears that the disease can be transmitted by the intermediary of insects (flies).

**Botriomycosis.** — At the present time botriomycosis is held to be caused by staphylococci which are able to become differentiated inside the body into clubbed forms (Magrour). The disease has been met with in veterinary surgeons who have been treating sick animals (Koch, 1897; Parascandolo, 1900), in gatherers of roses (Revillet, 1914; P. White). In this case the lesion has been found on the thumb and index finger of the right hand. This form of botriomycosis often seems to be due to the same agent as that got from animals (Habermann), and it is only from a clinical point of view that it presents any analogy. The last word on this, however, has not yet been spoken.

According to recent investigations, it is clear that a true human botriomycosis exists; it is, however, very rare, for up to the present only three cases have been met with (Kaiser and Gryns, Masson, Fumagalli).

**Butchers' pemphigus.** — This generalised disease has been described chiefly by American dermatologists among butchers and persons in contact with animal debris in the large centres of the food industry. The disease is usually serious and often fatal. Some writers have established a relation between this affection and aphthous ulceration and the meningococcus (Hofman and Dor, 1907; Parascandolo, 1900), in gatherers of roses (Revillet, 1914; P. White). In this case the lesion has been found on the thumb and index finger of the right hand. This form of botriomycosis often seems to be due to the same agent as that got from animals (Habermann), and it is only from a clinical point of view that it presents any analogy. The last word on this, however, has not yet been spoken.

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**Canadian pustulous dermatitis.** — This is a contagious affection due to a pseudobacillus tuberculosis, the so-called * acne bacillus* which can be transmitted to man, notably to persons who have charge of or look after sick horses (Galloway). It seems that this affection has been confused with the variola of the horse family.

**Cerebro-spinal meningitis.** — This disease is due to the meningococcus of Weichselbaum and to other microbes presenting the same morphological characteristics. It may appear in a sporadic form, but it usually assumes an epidemic form, which often confines itself to certain groups, being localised even to districts, houses or families. Bad sanitation, defective feeding, fatigue, overstrain and
Infectious Diseases

Climatic conditions are factors which favour the multiplication and virulence of the germ. The spread of the disease is often due to germ carriers. Some epidemics have been reported among mining and working populations (Germany, 1965, etc.). The disease constitutes an occupational risk for nursing staff attending to patients suffering from this disease.

Cholera. — This disease is endemic in India, especially in the regions of the delta of the Ganges; it made its first appearance in Europe in the sixteenth century.

Danger of infection is particularly great for doctors, nurses, sanitary inspectors and all those who are employed in treating and isolating cholera patients. The disease may also attack workers in scientific laboratories (Sata, 1927).

Cholera infection can be conveyed to a doctor's patients, by the intermediary of vibrio carriers, or by articles of food infected directly or indirectly by infected excreta. The disease was reported in 1923 among labourers at Vizagapatam (Madras).

Asiatic cholera is compensated in Queensland among hospital personnel, and in Yugoslavia.

Coccidiosis. — This parasitic affection is due to the presence of different kinds of coccidia which are found in the epithelial cells of the biliary canals and the intestinal glands. Cases of granuloma due to coccidia, beginning with pulmonary symptoms and spreading to the whole system, are known (S. Pulford and E. Larson, 1929).

Ravoli and other experts have reported cases occupational in origin. Timpano attributes to coccidia (Accleria Berleste, Leptus autumnalis) a form of cutaneous irritation, rhinitis and conjunctivitis met with among reed peelers (Arundo donax). It is true that cases of dermatitis due to oidiomycetes have been described under the name of coccidioses; these cases of dermatitis may be quite easily cured when the patient has been in contact with a sick animal.

The author thinks that this case was the first case of its kind.

See "Pustules", "Microsporosis" and "Trichophytoses".

Diphtheria. — This acute infectious disease, which is epidemic and contagious, is caused by the Klebs-Loeffler bacillus.

The bacillus is found in most cases in the pharynx, but may develop in any other region.

A doctor practising in an industrial town or populous centre is well acquainted with the peculiar gravity of the disease in case of overcrowding. During epidemics the number of germ carriers, which is considerable, facilitates the spread of the disease.

At the present time serum treatment has greatly diminished the mortality from diphtheria. Vaccination against the disease will make it still less common.

The persons who are most liable to contract the disease on account of their occupation are doctors and nurses, as well as, in certain occupations. This disease is compensated in Queensland when it attacks hospital personnel.
Dysenteries. — The term "dysentery" is applied to a well-characterised clinical syndrome, which includes amoebic and parasitic diseases, very diverse in origin, located in the intestines. There is generally a lesion of the mucous membrane of the colon and rectum which causes sanguineous stools.

For the purpose of this article it is sufficient to say that at the present time amoebic dysentery is recognised which presents an epidemic character and occurs in the temperate regions; it is due to the bacillus dysenteriae (Shiga and Flexner). A separate entity is the amoebic dysentery, which develops slowly, rages chiefly in tropical and sub-tropical regions and is due to entamoeba histolytica (tetragenae). This is the most common form, for amoebic dysentery claims certainly more than eight-tenths of the chronic cases. In other chronic cases the dysenteries are due to two other very extensively distributed organisms which are often found poor condition, exhausted, and congested of the glands, fever and pricking due to alcoholism.

Exanthematic typhus. — This acute disease shows itself in the form of a typhic condition and a characteristic rash, discreet at first, but rapidly becoming purpuric; it is accompanied by bloody effusions from the conjunctive and pharynx. The temperature is very high and often accompanied by delirium. The cause of the disease is an unknown virus transmitted by ectoparasites (lice). Typhus is compensated in Germany when it attacks sailors.

Favus. — This affection is caused by a fungus of the achorion genus (A. Schönlentin) which attacks the scalp, as well as the hairless parts and nails, giving rise to characteristic changes. In the scale when the parasite has reached its full development, formations occur which have a crusted appearance (scabs) with a sulphur yellow colour. The greatest part of these crusts is composed of masses of fungi; on hairless parts the presence of the parasite is manifested in the form of red patches covered with scales; on the nails are found thickenings, while the nail becomes opaque, brittle, irregular and of a greyish white colour.

Various kinds of favus which affect either animals can also be found in human beings. The clinical diagnosis does not as a rule present any difficulty; it is confirmed by microscopical search for the fungus in the crusts after they have first been treated with caustic potash (40 per cent.) or finally by cultures.

Gaseous oedema. — See "Septic vibrio".

Infections. — Common localised infections having as their starting point small abrasions of the skin or small injuries, are quite common in the course of manual labour. They are usually caused by staphylococi or streptococi. Although not serious so long as the trouble is localised, such infections may become particularly grave if they become general. (See "Septicaemia").

Infestous anaemia of the horse. — This affection, to which the name of "parasitic anaemia of the horse" has been wrongly given, is caused by a still unknown filtrable virus; it has been observed in a person who became infected during some laboratory researches on the disease. The symptoms consisted in intestinal disorders, cephalalgia, lumbar pains, wasting and anaemia. At the end of some
weeks the patient showed abdominal
herpes zoster, a rose rash and an inter-
mittent spotty fever oscillating about 39°C.
(Lührs).

Infectious jaundice (Weil's disease). — See "Spirochaetosis".

Influenza. — This infectious disease is
due to a coccobacillus isolated by Pfeiffer;
it is manifested clinically by fever, pains
in the back and limbs, joint pains, cephal-
algia and varying visceral disturbances.
Thus pulmonary and intestinal influenza
and influenzal meningitis are mentioned.
The working classes seem to be par-
ticularly affected during an epidemic,
and usually the pulmonary forms pre-
dominate. Working women are attacked
with more serious symptoms than men,
especially in the manufacture of tobacco
(Tedeschi). Moreover, when working in
fumes show a certain immunity against
nasal and respiratory catarrhs in general.
Thus, A. Gregor found that workers in
cordite factories, gas works and tin mines,
exposed to fumes, were affected much less
seriously than workers in the same kind
of work not exposed to fumes, and than
soldiers and sailors. On the other hand,
E. J. Ball thinks that fumes containing
sulphocyanide favour the protection of the
workers. Further, Frank Shuflebotham
found that it was chiefly men employed
on work in which fumes of sulphurised
hydrogen, chloropicrine, chlorine and mus-
tard gas (dichlorelthyl sulphide) were
generated who were protected against influenzal
infection. Walker has described
a case of infection in a laboratory due
to the coccobacillus of Pfeiffer: the symp-
toms consisted in rhinitis, conjunctivitis
and bronchitis without fever.

Lambliosis. — A disease due to the
Lambia intestinalis, a parasite of the
order of polymastigia which has four to
eight flagellae. Some cases of intestinal
infection in miners have been observed in
Germany (Teitge).

Leishmanioises. — These are diseases
due to protozoa (Leishmania) which are
grouped in two categories: those localised
to the viscera, which lead to infantile
splenic anaemia and especially to Indian
Kala azar; and those whose localisation is
cutaneous and muco-cutaneous which lead
to Kala azar; and those whose localisation is
splenic anaemia and especially to Indian
measles. — This infectious disease is
due to a parasite of the muconine order
(Lichthemia Italice), isolated in 1913 by
Perin in theexpectoration of a country-
woman, who succumbed to the disease.
In 1923 Perin and Ricci again found the
same parasite in a peasant who showed as
clinical symptoms, cough, hemoptysis
and asthma. Lichthemia has also been
found on maize, in manure and in the
dust of the harvest.

Marsh fever. — Still described under
the name of mud fever this disease
caused in 1928 a small epidemic in the
flooded regions of the Oder, where the
same infection had been previously ob-
served. The disease affected chiefly young
persons of 14 to 25 years who had been
working in flooded areas. Clinically, it
shows itself by premonitory fatigue, fol-
lowed by violent cephalalgia, high tem-
perature, stiffness in the back and limbs,
anorexia and tremors. Vertigo, muscular
pains, rachialgia and often abdominal
pains may also be present. Objectively,
conjunctivitis and congestion of the face
are found. The temperature may reach
40°C; it remains so for five to seven
days and is accompanied by intense
sweating and varying exanthems.

The etiology of the disease remains
obscure and its diagnosis is often confused
with influenza and dengue. Prognosis is
usually good. The number of cases ob-
served up to the present time exceeds a
hundred (Werner).

Measles is an infectious disease charac-
terised by a rash which is preceded by
an ocúló-nasal catarrh. Infection can
only occur directly. The disease itself is
comparatively benign in children, but
may assume at the onset a malignant
character in adults. From the occupa-
tional point of view it is only of impor-
tance as regards persons employed in
hospitals or who come directly in contact
with the patients. This disease is com-
pensated in Queensland when it attacks
hospital personnel

Mediterranean fever. — This infectious
disease is also known as "undulant fever"; it is common to man and some
animals (goats especially); it is endemo-
epidemic in the basin of the Mediterranean
from whence comes its name, and is due
to Micrococcus melitensis Bruce. In man
it is characterised clinically by copious
sweats, persistent pains and especially by
successive rises of temperature of long
duration (undulant fever). It is found
fairly often among goat-keepers and persons who come in constant contact with goats or sheep (Imbert); and it can be easily transmitted in the case of wandering herds not subject to adequate sanitary supervision. For this reason France decided in 1923 to bring into force a series of protective measures against the spread of the disease. Imbert in a thesis, published in 1938, collected 70 cases in the Ardèche, in half of which contagion by simple contact was the source of the disease; he shows how liable butchers are to undulant fever (4 cases).

At the present time the question of identity between the agent of human undulant fever and the bacillus abortus (bacillus of Bang), which causes epizootic diseases among bovines, is under discussion. Recently some authorities have expressed the opinion that there is only one and the same agent, which in passing from man to the animal and vice versa presents its essential specific qualities, though subject to certain biological changes. The practical importance of the problem is obvious. For a long time it was believed that undulant fever was only propagated by goats; but it has since been found that it may also occur in sheep, horses, dogs, rats and even cows. Thus the possibility must be allowed of infection by means of milk and dairy products; moreover, such infection has been confirmed in carefully controlled cases.

A case of laboratory infection due to the micrococcus of undulant fever has been reported by Professor Carbone, of Parma.

Microsporosis. — This affection of the smooth parts and the hair is caused by various kinds of the microsporon genus and notably that of M. Audouini in the case of man. The disease can be transmitted by various animals, such as the dog, cat and horse, in which microsporases are quite common. Transmission from man to man may occur as with other dermatophytes.

Mumps is an infectious disease characterised by inflammation of the salivary glands and particularly of the parotids. It is included in the list of occupational diseases in Queensland when it attacks the personnel of hospitals.

Noma. — The affection is caused by a necrosing bacillus which has been identified with the bacillus of diphtheria of calves. Clinically, it causes the formation of an abscess and deep ulceration. Jensen has reported some cases of noma as affecting persons employed in laboratories.

Oriental sore. — This affection, which is still known under the names of "Aleppo boil", "Cutaneous Leishmaniasis" or "Biskra boil", takes the form of a parasitic skin granuloma produced by Leishmania tropica or Leishmania farcibercolata. After a somewhat variable period of incubation it appears on uncovered parts of the skin as a pruriginous papule, surrounded by a hyperaemic areola which opens, forming generally a single ulcer with infiltrated edges and a violet red fungating base.

Certain species of mosquitoes or bugs (Cimex lectularius) are regarded as the agents of transmission. Two autochthonous cases of oriental sore have been reported in France, in 1930 and 1936, among workers at the ports.

Oroya fever. — See "Peruvian wart".

Pernicious anæmia of the quebradas (ravines). — See "Peruvian wart".

Peruvian wart. — This infectious disease, still known under the name of "Oroya fever", is characterised by fever, marked anæmia and a warty cutaneous eruption. The disease only occurs in some regions of the Cordilleras in the Andes.

Oroya fever in 1870 attacked the workmen employed in constructing a railway between Lima and Oroya. Further, all the workmen employed in making the railway across the Andes contracted Peruvian wart. In 50 per cent. of the cases the disease was fatal (Bourse). Peruvian doctors regard Oroya fever and Peruvian wart as two manifestations of one and the same morbid condition. Experimental proof of this fact was established in 1885 when a medical student, Daniel Carrion, a native of a locality where the disease is endemic, inoculated himself with the wart and became ill twenty-three days after with Oroya fever, from which he died at the end of two weeks. However, in 1913 the Strong mission decided on the duality of the two diseases, thus distinguishing a febrile and malignant form which is generally fatal (Oroya fever) and an eruptive form which has a benign character (Peruvian wart). As a matter of fact, the geographical distribution of the two diseases is not always the same; and there are places where only one or other of the affections is met with. Oroya fever, known also under the name of "pernicious anæmia of the Quebradas", is due to a microbe which has been found in the blood of patients, and recovered by observers in the tissue of the warts. The pathological agent is transmitted by an insect of the blood-sucking genus (P. verrucarum, P. nuyuchii).

Plague is an epidemic disease transmissible directly to man or by the intermediaiy of animals (rodents, ectoparasites), due to the bacillus of Yersin; it is characterised by a typhoid state which rapidly becomes serious. The appearance of buboes, petechiae and pulmonary signs constitute very grave complications which are especially contagious and fatal.

The transmission of plague to a distance takes place on land by rats and fleas, assisted by the increase in the number of roads and railways. On the other hand, in maritime conditions the chief transmitting agents are rats which infest grain-carrying ships. A man during the incubation period of plague, or as a carrier of infected fleas, may also convey the disease to a distance.
Direct contagion, except in the case of the paralytic form, is rare. Contagion of human origin occurs usually through underclothing and clothes which have belonged to a patient, although the bacillus is not at all resistant to light and dryness. There are several cases recorded of plague attacking doctors, either during epidemics or in laboratories during research work. Certain occupational classes are very much exposed to the contagion, notably transport workers and especially dockers, seamen and railway workers. Among other occupations should be mentioned: hunters, for example, tarabagan hunters in the Mongolian steppes; rag sorters, among whom epidemics occurred in 1913 at St. Barnabas' cardboard factory at Marseilles, in 1916 at Bristol, and in 1920 at Paris; in Manchuria some coolies have been infected by their donkeys (shibayama). At Sargo a dyeworks was infected on two different occasions, in 1906 and 1914, plague having been brought in by rats hidden in boxes containing old dresses for cleaning or dyeing.

In well-managed hospitals the risk of infection of the medical and nursing staffs is extremely rare, as is known from experience gained in India (Hankin). That does not imply any harmlessness for the virus, since frequent cases of infection due to hands infected by pus from a recent bubo, from pricks during autopsies and from contaminations from excreta, are on record. Epidemics are even known to have started from infection in laboratories, though this has not often happened (Vienna, 1893; Preston, 1910; Ruisseau near Algiers, 1912; Tangiers, 1914, etc.). In the pneumonic form of plague enormous quantities of bacilli are scattered into the surrounding air by the patient during coughing. Plague is compensated by the Governments of Yugoslavia and Japan if contracted during the handling of rags, hair and skins, and by Queensland for hospital personnel.

Psittacosis. This disease which is still called "parrots' typhus" (Peter) was recognised for the first time in France in 1892 during an outbreak which occurred among parakeets imported from Brazil. It was transmitted to some persons who conveyed or had charge of the birds. It was Nocard who first isolated, in 1892, the bacillus which bears his name, and called the disease "psittacosis". It is believed that this bacillus belongs to the B. paratyphoid group; Perry (1920) found it to be identical to the B. aertrycke (Mutton), and to the B. typhi murium. It has now become classified in the Salmonella group, whilst other experts consider it to be a virus capable of filtration, opening the way to other germs, and especially to streptococci, to the bacillus of Nocard, etc. The disease recalls the clinical picture of typhoid fever, and most of the symptoms of atypical pneumonia. Coughing is fairly frequent. The mortality rate is very high. A fatal case has been reported (1930) in the United States as occurring to a laboratory assistant engaged in looking after parakeets. Eleven laboratory assistants in the Federal Hygiene Service have been attacked by psittacosis during research work.

Rabies. This disease, which is peculiar to the dog, wolf, and other animals (foxes, cats, the equine species, goats, pigs, etc.) may be transmitted to man by bites, by licking of the apparently healthy mucous membrane, or by soiling of wounds with foam from the mouth. According to Levaditi and his collaborators, the rabies parasite is a microspore or a parasite belonging to a similar group. The bodies which Negri succeeded in demonstrating in the nervous cells, especially on the limb (hippocampus), are said to constitute the pan-sporoblastic phase of its cycle of development, a phase which is lacking in the fixed virus. The occupational risk is great for all those who have frequent opportunity of living close to animals susceptible to the disease: hunters, breeders, owners of dogs, stable boys, cowherds, veterinary surgeons, carters, employees in furriers' workrooms, sailors, etc. Though the rabies virus is delicate, without possibility of conservation except in the patient, it is also capable of becoming attached to inanimate objects and polluting these dangerously during an appreciable time, and by way of these coming in contact with the tissue and giving rise to the disease. In this way are explained several cases, some of which have even been quoted by ancient writers (Caesium Aurelianus, for instance) and nearer our time by Porta, Enaux, and Chaussie (1795), Barsley, Ricchole (1893), Remigler (1906), Engel, Koevaloff (1923), Krauss, Gerlach and Schweinburg, etc., cases which prove the possibility of contagion sometimes of occupational origin, quite apart from infection due to bites.

In man the disease commences by a period of incubation lasting from fifteen to sixty days, sometimes even longer, with a change in the patient's humour, which is variable, anxious, with phenomena of insensibility, but more often of hyperaesthesia, at the seat of the bite. There follows a slight increase of temperature, with more and more abundant flow of saliva, as well as increasing cramp on swallowing, accompanied by respiratory trouble. The anxious state gets worse. The muscles of the trunk and of the limbs are affected by cramps caused by the least sensory stimulus. There is loss of consciousness except for short intervals of tranquillity. Death occurs as a result of paralysis, with symptoms of cardiac weakness and marked fever.

The anti-rabies vaccination of Pasteur is very well known, and its practical value is so much the greater the earlier it is applied. In the case of individuals bitten by a mad dog and treated by vaccination, mortality has fallen from between 30 and 40 to about 0.5 to 1.5 per cent.
Rabies is subject to compulsory notification as an occupational disease in the State of Illinois.

Rat bite fever. — See "Sodoku".

Recurrent fever. — A disease known as recurrent fever, and also under the name of "recurrent typhus", is due to a spirochaete (S. Obermeyeri. S. Duttoni, S. lutea, S. Novyi, S. Carteri) which manifests itself by an attack of continued fever often followed by one or several relapses. It is transmitted to man by means of parasitic insects which seem to be of different kinds according to the different varieties of recurrent fever.

A case of laboratory infection by the conjunctiva was reported in Russia in 1928 at the medical clinic of Kazan (Ivanowa).

Rheumatisms. — Under the name of rheumatism are grouped joint affections, and muscular and nervous conditions which very often affect the working population. It has been shown that acute polyarticular rheumatism is an infectious disease. The germ, however, has not yet been isolated. On the other hand, in forms of chronic rheumatism an important part is played by the influence of tuberculosis. Generally hard physical work, with exposure to bad weather conditions, draughts, wind, rain, dampness, and high temperatures, is a predominating factor for rheumatism. As a matter of fact this affection is often met with in bakers, stokers, laundry women and land-workers, and among the last named chiefly in the form of lumbago. The clinical forms vary according to the position of the pains. Rheumatism of the shoulders (Omalgia rheumatica), sciatica, muscular rheumatism and chronic arthritis deformans are all recognised. Rheumatism in the acute febrile form is especially dangerous for the heart.

According to the Minister of Health of Great Britain, there are registered annually in England and Wales among persons insured against sickness, 90,000 cases of lumbago, 22,000 cases of sciatica and 56,000 cases of muscular rheumatism; more than 50,000 insured women are each year victims of these diseases. In Great Britain it is estimated that rheumatism is responsible for 80 per cent. of deaths due to diseases of the heart among young persons below twenty years of age.

It is generally considered that rheumatism is favoured by the bad social conditions under which poor children live. It is in consequence proposed to subject to close supervision all children under fourteen years, it having been found that very often the disease begins in early infancy.

Some idea of the importance and extent of rheumatism among workers may be obtained when it is considered that in Great Britain the disease in 1927 caused a loss of 5,500,000 working weeks and represented a charge of 5 million pounds sterling for the budget of the national health insurance. The same hard, for this same period a sum of 12 million pounds sterling represented the loss of wages sustained by the insured sick persons.

Rocky Mountains spotted fever. — This affection, which is still known under the name of "tick fever", is an infectious disease caused by unknown germs and transmitted by the Dermacentor andersoni Banks, an acarus of the ixodide family. The disease begins by cephalalgia and articular pains. The incubation period is from one to eleven days. The fever, which is remittent, reaches at the end of ten to twelve days 39.5° to 40° C., and falls between the fourteenth and eighteenth day. There is at the same time an acceleration of the pulse to 110 up to 140, and of respiration to 25 up to 50 and even 60 respirations a minute. The predominant symptom is a rash which commences at the wrist and ankle and extends to the forehead, back, chest, and then to the abdomen. The rash may become confluent and form petechiae. The differential diagnosis is difficult on its appearance from a typhus rash. The disease has been observed among forest workers in the Rocky Mountains, especially in the States of Montana and Idaho.

Doctors and laboratory workers have also been among the victims of tick fever. Up to the present 4 cases have been reported, of which the most recent, in 1928, occurred in one of Hamilton's laboratory assistants who contracted a fatal illness from handling the virus.

Rouget is an infectious disease giving rise to outbreaks in swine and transmissible to man. According to Arkwright (1918), cases of rouget in man are actually rare. It is not even certain that all the cases described up to now have been accurately diagnosed. In the last half of the nineteenth century several cases of stomatitis were attributed to rouget, at a time when this disease was raging among the herds. Most of the cases were due to taking milk. In some other cases it was possible to establish an epidemiological origin for the infection, such as contact with diseased animals or butchering. However that may be, the question has not been cleared up and the general opinion is that it is not rouget, but angina and fever due to streptococci or to other bacteria transmitted by a mammitis of cows. On the other hand, secondary infections occurring in animals attacked with aphthous fever have been suspected.

At the present time the identity of this affection with orysipeloid is almost generally admitted (see "Erysipelae").

Scarlet fever. — This infectious epidemic disease occurs chiefly among children. The symptoms are sore throat, enlargement of the lymphatic glands, disorders of the circulatory and nervous systems, with a rise of temperature to 40° C. and more, and a red rash which has given to the disease its name. In serious cases scarlet fever is complicated by nephritis and various inflammations of organs, due to secondary infections.
The disease usually runs its course in two or three weeks, after which desquamation of the skin commences. Two cases of laboratory infection were reported by Moltke and Poulsen in 1929. Among adults scarlet fever is an occupational risk for the personnel of infectious hospitals, for rag sorters, and in general for every person in contact with patients with yellow fever, or with rats, due to the disease called "rat bite fever". Septic oedema is met with in agricultural infections, and is also quite common, especially in Japan, doctors and in particular all laboratory workers, just as all who come in contact with rats, may be infected by the spirochaete of haemorrhagic jaundice. The supply of virus may come either from man in the case of typhus, or from an animal, such as the rat for sodoku and haemorrhagic jaundice. It is almost certain that cases formerly diagnosed as infective jaundice, febrile jaundice, jaundice fever or relapsing jaundice were really cases of haemorrhagic spirochaetal jaundice. Septicemia, pyaemia. — Under this heading are now understood serious morbid conditions characterised by the presence of microbes in the blood. In consequence, one may say that there are as many varieties of septicaemia as there are pathogenic micro-organisms capable of passing into the blood and of developing there. The penetration of microorganisms into the blood takes place under the most varied conditions: pricks, wounds or other injuries which are sometimes quite negligible in themselves. Any infected focus, whether a whitlow, abscess, phlegmons, chilblains, or certain diseases, such as erysipelas or pneumonia, whether suppurating or not, may cause a septicaemia. Septic pyaemia presents a collection of ordinary symptoms: shivering, fever, sweating, prostration and secondary deposits. It is sufficient to say that septic-pyaemia from streptococcic infection is the most common, for this microbe exists in the state of a saprophyte on the mucous membranes and possesses a great aptitude for growing in the human blood. Septicaemia from staphylococcic infection is also quite common, especially as an infection secondary to a staphylococcic lesion of the skin where this microbe is found in the saprophytic state.

Septic vibrio. — The septicaemia of septic vibrio which is accompanied by septic oedema is met with in agricultural workers who handle manure (Antonelli). (See article "Agricultural Labourers").

Sodoku. — Still known under the name of "rat bite fever", this disease, which is due to a spirochaete called by Noguchi Spiroplasma Sodoku, is characterised by shiverings, fever, a generalised eruption and inflammatory appearances at the site of the bite. In the case of a bitten finger, this is the most common, especially as an infection secondary to a staphyloccic lesion of the skin where this microbe is found in the saprophytic state. The course of the disease varies from three days to three, four and even more weeks. An abortive form has been described, also a form confined to the region of the bite, and a nervous and a renal form.

Spirochaetosis. — This is a group of acute diseases caused by pathological spirochaetes; it includes recurrent typhus, leper-haemorrhagic spirochaetosis, trench fever, sodoku, and, according to some authorities, yellow fever, which Noguchi attributes to spirochaetes (leptospira icteroides). The characteristic feature of acute spirochaetoses lies in the temperature chart, the presence of jaundice and the absence of direct contagion from man to man. Transmission occurs by the intermediary of an ectoparasite (the louse for recurrent typhus) or mosquito (the stegomyia for yellow fever). The supply of virus may come either from man in the case of typhus, or from an animal, such as the rat for sodoku and haemorrhagic jaundice.

Sporomycosis. — Under this name there was described, in 1928 a benign affection occurring in summer in persons in perfect health, running a course of some weeks and clearing up when the patients had been removed from the infected locality. Clinically symptoms of tracheo-bronchitis, digestive disorders, asthenia, myalgia and wasting were found. The Aspergillus fumigatus and Mucor mucedo were regarded as the cause of the disease. The symptoms commenced as early as the month of May and attacked chiefly men who were sweeping up grain (Pasteur Vallery-Radot and Paul Giraud).

Sporotrichosis. — This affection is a mycosis common to man and animals, due to a fungus known as Sporotrichum
Beurnmanni. For a long time this infection was confounded with syphilis and tuberculosis, its clinical character having been defined only in 1909. The parasite, which was isolated and cultivated in 1905, is very widespread in nature: it is found in the saprophytic state on equiseta and on oats. It develops spontaneously in such mammals as dogs, horses, and rats, and in insects, so that all these intermediaries may serve to transmit the disease to man. Infection may occur at the site of an accidental injury, even though quite minute, or by the digestive organs, or even through the healthy skin or at the junction of the bulbar and palpebral conjunctiva. Accidental infections in the laboratory are frequent.

The disease attacks agricultural workers, sellers of grain, fruit, flowers and vegetables, and men employed in transport work, drivers, stable boys and veterinary surgeons. The disease has been found in almost every country, the frequency varying from one place to another.

Trichophytosis. — This group of skin affections which attacks the epidermis, hair or nails, is due to various kinds of fungi of the Trichophyton genus. The trichophytosis caused by the *trichophyton cutaneum* of Breslau is characterised by an eruption of squamous erythematous or vesiculo-erythematous patches which are pruriginous and are situated in the inguinal, ano-vaginal, axillary and mammary regions. The disease is caused by an agent as yet unknown; it occurs amongst cattle where it is not known in other parts of the world. Out of 614 cases observed, 20 ended fatally. Numerous cases of tularaemia were caused in 1928 in a village in the Urals by the water-rat, which is hunted for its skin. The Health Service of the Ural district has published a notice containing hygienic and preventive recommendations for hunters of water-rats.

The symptoms appear forty-eight hours after infection, which most often occurs from a bite; they consist of fever and pains in the vicinity of the glands to which the bitten area is drained. A marked affection of the glands characterised by great swelling and violent pain, passes on to suppuration. The duration of the disease varies from three to six weeks, with a feverish condition like that of septicaemia. Convalescence is slow. A form complicated by conjunctivitis and a typhoid form have been described. The occupations in which the disease has been observed are: cooks, gamekeepers, housekeepers, market-stall keepers, and, in general, those who skin and cut up rabbits when preparing bait for fish or coyotes, or food for foxes, owls or pigs.

Typhoid fever. — Under this head are included all conditions impairing the activity of the subject, even temporarily, in which the presence of agents of the typhoid group are found by laboratory tests (Lenglet and Ayrignac). To this group belong the typhoid bacilli properly so called (Bac. of Eberth, *Paratyphoid bacillus A*, *Paratyphoid bacillus B*), and the *Salmonellosis bacilli* which can only be distinguished from each other by secondary clinical and bacteriological characteristics.

The infection generally occurs by ingestion, and only occasionally by the respiratory passages. Fatigue and defective nutrition explain the intensity and gravity of typhoid conditions, especially in tropical countries.

In 1929 Achard reported the results of his observations relative to a woman employed in a laboratory in sealing
capsules of anti-typhoid T.A.B. vaccine, which, in error, had not been sterilised. Her fingers were soiled, and even her face, by projections of the microbic emulsion. She developed ordinary typhoid fever after a very short period of incubation. Achard also insists on the frequency of contagion due to dirty hands (care in regard to manipulation of soiled basins, sheets, shirts, etc.) amongst nurses and doctors, etc. Perspiration of the hands probably favours numerous cases of indirect contamination.

Dissemination of the infectious agent by various forms of organic matter and by such things as water, food, soil, clothes and underclothing, in which it is preserved for months, explains the virulence of typhoid bacilli, after periods more or less prolonged. Damp air, dust and flies may convey the bacilli. Carriers of the bacilli play an important part in the transmission of the disease; and the danger is especially great in the case of persons employed in the manufacture of food products or in the preparation of food, and butchers, dairymen, pork butchers, gardeners and cooks. Infection by excreta from patients is by far the most common source; and the chief vehicle is the water supply which should always be suspected in any epidemic of a serious nature. Next to water, soil which preserves the bacilli brought to it by manure, excreta which foul it, the hands and articles of persons who have been in contact with patients or carriers of bacilli, are means for spreading the disease. The disease is compensated in Queensland when it attacks hospital personnel.

Preventive vaccination should be compulsory for every worker called on to handle live or dead typhoid germs (Achard).

Vaccinia is a disease which is common among bovines and members of the horse family, where it takes the form of a localised affection which is usually benign. It is from these animals that man may become infected. Among swine and goats, the disease is more dangerous. The infection attacks horse keepers, stable boys, agricultural labourers and veterinary surgeons. Many cases of vaccinia are known to have occurred in men, which have been transmitted from cows. The patient presents vesicles and pustules, and sometimes localised nodules, in the affected skin region. Ran and De Jong have described a form of vaccinia localised in the ear and on the external auditory meatus.

During an epidemic of vaccinia in 1909, out of 21 milkers, 22 were infected, although most of them had been vaccinated during infancy. Small epidemics are met with among farm labourers which affect from ten to twenty persons (Tryb). Some cases known under the name of "Manké" have been confused with vaccinia; they are regarded now as eczema. Typical cases of vaccinia are rare nowadays for vaccination has certainly diminished the frequency of the disease.

Variola or smallpox. — This disease which in the old days used to rage in epidemic form in every country, has become more and more rare since general vaccination of the population. Danger of infection, however, exists when merchandise infected by variola is imported into industrial regions which have been hitherto exempt. Thus in France in 1925 some cases of infection were reported in four departments with several deaths and threats of serious epidemics (Camus). Apart from vaccination, prevention of the spread of the disease should be ensured by careful disinfection of merchandise liable to transmit the infection.

This disease is compensated in Queensland when it attacks hospital personnel.

Warts are papillomatous excrescences of the skin common in domestic and wild animals, fish and birds. In spite of the positive result of transplantation experiments and of transmission by contact, the natural infection of man by an animal is quite rare. Cases of infection by foxers, transmitted from foxes, are recorded.

Yellow fever. — The infectious disease known as yellow fever runs a rapid course; it is caused by a virus, the nature of which has not yet been determined, but it seems to belong to the spirochaete genus. The virus carrying agent is a mosquito of the Stegomyia family (S. fasciata or S. Calopus). The disease attacks chiefly agricultural workers who, apart from vaccination, prevention of the spread of the disease is compensated in Queensland.

This disease is compensated by the Government of Yugoslavia.

LEGISLATION

In Germany, since February 1929, "Infectious diseases" have been compensated when they attack the personnel: of hospitals, maternity homes and other similar institutions which take in persons for treatment, as well as general and public or private associations for social
aid; of the public health service; of laboratories for research and scientific experiments whether for natural science or medicine. Infectious diseases which are characteristic of tropical and sub-tropical countries, viz. malaria, dysentery, yellow fever, sleeping sickness, dengue, plague, undulant fever, framboesa and anktylosomiasis, are compensated when the latter when it attack seamen in the merchant service (not those on inland waterways).

These diseases are compensated in Hungary when they attack agricultural labourers; in Queensland (smallpox, typhoid fever, diphtheria, bubonic plague, measles, mumps, scarlet fever, when they attack hospital personnel); in Western Australia when they attack sanitary officials; in the State of Ohio when they are a complication of local lesions caused by oils, lubricants, dust or liquids; in Austria since 1928, when they occur among the personnel of scientific laboratories.

In Lithuania and Yugoslavia, compensation is granted for epidemic and tropical diseases in the mercantile marine.

Septicaemia is compensated in the States of Victoria and Queensland (in the latter when it attacks persons employed in handling meat and animal products, in carding and sorting wool, in handling skins and hides, wools, horsehair, hair, hog bristles or carcases of animals).

In some countries certain cases of infection, such as anthrax and plague, are considered as accidents, so that the actual tendency, as for example in Italy, is to regard sections of an occupational origin as industrial accidents and to compensate them accordingly.

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**IODINE**

**Iodine**


**CHEMICAL PROPERTIES**

Iodine (symbol I), discovered in 1812 by Courtois, is a product widely disseminated in nature in combination with other substances and often accompanied by a compound of chlorine and bromine. It is likewise found in the state of iodides and iodates (of mercury, silver and lead), in certain ores, in Chilian nitre (sodium nitrate), in certain mineral waters (iodides of magnesium and sodium), especially in sea water (0.002 grm. per litre), whence it passes into certain types of plants, e.g. seaweed (*Fucus vesiculosus*, kelp, lamnaria), and certain marine animals, e.g. sponges and mollusks.

In the pure state, iodine occurs in the form of large rhombic plates of a blackish violet colour, with a metallic and a peculiar smell which at 114° boils in water, and the sodium and potassium chlorides, which is highly irritant and which, like its crystals, dye the skin and organic substances dark yellow. The fumes become recondensed without passing into a liquid state, and are sublimated in bright black crystals. It is very slightly soluble in water (1 part per 3,000); it dissolves easily in an aqueous solution of iodine of potassium, in alcohol, ether, chloroform, carbon disulphide (which dissolves 33 per cent. of it), etc. Used with starch, typical violet coloration is obtained, which disappears when subjected to heat.

Iodine is very much used in the preparation of alkaline and organic iodides of certain organic colours (violet and green iodine, tetraiodofluorescin), photographic preparations, in chemical laboratories, in medicine, etc.

In combination with a solution of ammonia, and in part with a solution of salts of ammonium, iodine may give rise to explosion. The product known as "brom-iodine", which is very much used in the photographic industry, has a highly irritant action.

**INDUSTRIAL PROCESSES**

The treatment of seaweed (kelp) still followed in Great Britain, France, Japan, etc., for a long time constituted the sole means of preparing iodine. The seaweed is dried in the sun or calcined in order to obtain the "sodas"; washing in water, followed by concentration of the liquors obtained and calcination, also furnishes a means of obtaining the "sodas" while conserving the organic substances contained in the seaweed.

The "sodas" or "ash" are again placed in water, and the sodium and potassium chlorides, as well as the soluble salts, are thus separated (sulphates, alkalines, carbonates). The mother liquor is treated by sulphuric acid, which decomposes the sulphide. Sulphur dioxide and sulphuretted hydrogen are given off, with formation of a precipitate of sulphur which is recuperated. The mother liquors, rich in iodides are thereafter distilled in the presence of manganese dioxide and sulphuric acid. Various processes are utilised. In accordance with one of these methods, the acidified mother liquor is distilled, recovered, condensed, and then manganese dioxide is introduced gradually up to the point at which the reddish violet fumes liberat-
iodine is recovered in the form of crusts, and the iodosides obtained as a second product are treated with chlorine (in the form of potassium chlorate and hydrochloric acid in accurately calculated quantities). The iodine separates out and is obtained as a solid on the surface, or in the bottom, of the recipient.

Another method consists in drying the iodoside solutions, which are then mixed with water and treated with sulphuric acid or potassium bichromate.

A third method finally utilises treatment of the mother liquors with copper sulphate or sulphate of iron in order to form copper iodoside, from which the iodine is ultimately extracted by distillation with sulphuric acid and oxide of iron.

Incineration of the seaweed may be avoided by distilling it directly in a retort.

In South America the iodine is extracted from crude sodium nitrate, the mother liquors coming from the refining of the nitre (with 0.5 per cent. of iodosides) being treated with bisulphate of soda or a solution of sulphur dioxide. The iodosides separate out in a solid mass. The iodosides are decomposed by the addition of a little water. The impure iodine (80 to 85 per cent.) is recovered and filtered.

Iodine may finally be extracted from the mother liquors of Stassfurt salts, or from iodosides by electrolytic process.

Crude iodine is purified by sublimation, which is effected in an earthen retort heated to a moderate degree in a sand bath. The fumes are recovered in a large earthen receptacle with a double bottom for separating the distillation water. The iodine is sublimated a second time to eliminate small traces of chlorine, of bromine and of water which it may still contain.

Amongst the compounds of iodine, mention is restricted to the following:

Methyl iodoside (CH₃I), prepared like ethyl iodoside with methyl alcohol, phosphorous and iodine, is a liquid with a density of 2.293, which boils at 45° C.; with much water at 100° C. It decomposes into HI and methyl alcohol. It is used chiefly in the preparation of methylated aniline colours.

Ethyl iodoside (C₂H₅I) is prepared by causing red phosphorus to be digested with absolute alcohol to which iodine is gradually added. It is heated and distilled in an air-bath, it is washed with dilute alcohol, then with water, and then dried with CaCl₂. It boils at 72.3° C. Ethyl iodoside decomposes slowly when exposed to light.

Allyl iodoside is similar, and is constituted like allyl bromide and allyl chloride.

Ethylene iodoside, similar to ethylene bromide, is distinctly toxic. It gives rise to cerebral troubles, with a sensation of violent oppression.

Cyanogen iodoside has been studied by Goldfarb (1891). It was formerly used as an anti-parasite for cattle.

Nitrogen iodoside is extremely explosive even on the slightest friction.

Iodine trichloride is very little used and is highly caustic.

For lead iodoside, see article, "Lead, Compounds of".

Iodoform or triiodomethane (CH₃I₃), discovered in 1822 by Serullas, is prepared by heating ethyl alcohol or acetone with iodine and the amount of alkaline hydrate or carbonate necessary for decolorising the iodine. Efforts are at present being made to discover a practical means of effecting this by electrolytic process.

**Pathology**

Iodine exercises an action which is similar to, though less intense than, that of bromine and chlorine. Inhalation of its fumes may cause, besides a local irritant and caustic action, acute or chronic poisoning. This action may, however, occur also as the result of ingestion of iodine (dust) or, more frequently, of its salts in the course of their manufacture or of their use. The contact with the skin of an aqueous solution of iodine and its salts may also, in the long run, lead to absorption of the product, especially if the skin is not injured.

When it exercises a general action on the system, iodine may give rise to methaemoglobinaemia, often accompanied by methaemoglobinuria (Lowy). Acute symptoms are represented, according to Ascher, by excitement, nervous manifestations, irritation of the mucous membrane. Two serious cases, one of which was fatal, have been reported by Schuler (1890-1891) in a Swiss factory for the manufacture of organic compounds of iodine. In the fatal case, the victim suffered from vomiting, diarrhoea, serious cerebral trouble, vertigo, double vision, dysuria and collapse.

Certain injuries met with among workers engaged in the preparation of iodine are due to chlorine and other products utilised in course of its manufacture.

On the skin, iodine gives rise to yellowish brown staining and in the long run to irritation due to its well-known vesicating action which, accord-
ing to the research engaged in on himself by Matt (1888), a pupil of Lehmann, is said to be still more marked than that due to chlorine or bromine. The skin becomes dry and peels off in strips. Oppenheim reports cases of dermatitis of endogenous origin in the form of vesicles, and bilateral, toxic dermocystosis and impetiginous eczema of the face, with acne and folliculitis. Zanker, Sabouraud, Prosser White and others have drawn attention to cases of dermatitis due to iodine among photographers and members of hospital staffs (doctors, nurses).

On the mucous membrane, the iodine exercises an irritant and caustic action: at the level of the eyes the fumes cause watering of the eyes with a burning sensation, inflammation of the blood vessels, and sometimes blepharitis and, in the case of concentrated fumes, opacity of the cornea. As regards the nasal mucous membrane, there have been reported rhinitis and, as regards the buccal mucous membrane, catarrhal stomatitis, with salivation and a tendency to ulceration. The teeth become tinged with yellow. Chevallier (1842) noted irritation of the upper respiratory passages, and a chronic case of pharyngitis. There has also been quoted a case of cramp of the glottis. Ascher, finally, has reported cases of irritation of the gastric mucous membrane, even to the point of laceration.

The organic compounds of iodine have given rise to several cases of very serious injury, for besides the irritant action similar to that of alkaline chlorides, they possess a narcotic effect which recalls that of methyl bromide. In 1891 Meine, of Basle, reported three cases of poisoning by methyl iodide. Grandhomme (1893) noted in a factory of Hochst-on-Maine, six cases — some of which were serious — of poisoning due to the same product amongst workers who were engaged in preparing anti-pyre. Jaquet (1901) has described another case of poisoning by methyl iodide, and mention should also be made here of the cases of Schuler, referred to above.

In the cases studied, the methyl iodide had given rise to nervous phenomena characterised by very accentuated psychical excitement, followed by narcosis. The patients complained of derangement of vision, of discomfort and vertigo. They had slow pulse and retarded cardiac activity, derangement of the sensory organs, an absence of the reflexes of the conjunctiva, etc. (Lewin, Guillery, etc.). Zangger recalls that ethyl iodide may cause paralysis (since it is a question of a neurotropic poison) and that methyl iodide may give rise to phenomena similar to those produced by nitrous gas, etc.

The injuries caused by iodoform are exclusively limited to dermatitis. There has been described a type of eczema ("greenish and chronic itch") with violent irritation. In the case of a doctor, manipulation of iodoform gauze caused a lesion followed by a papular and eczematous rash on the back of the fingers and of the hand (Hartzell, 1917).

In general, the palm of the hand is not attacked. On the back of the hand and on the fingers, there form, on the contrary, vesicles which become covered with a crust. When this falls, the lesion is constituted by fissures or painful rhagades, with thickening of the surrounding skin.

Another case of special susceptibility has been related by Bruno Bloch (1912). It was, according to this expert, an instance of hyper-sensibility of the skin in regard to the methyl group rather than hyper-sensibility in regard to iodine. The mucous membrane is said to be free from this hyper-sensibility.

**HYGIENE**

The hygiene measures indicated are those provided for all chemical operations involving liberation of toxic fumes: processes in closed receptacles or, in certain cases, with effective ventilation (accompanied by natural recovery of the fumes containing the product). In the Swiss factory where two serious cases of poisoning occurred due to organic compounds of iodine, medical examination of the workers every three days, with analysis for detection of iodine in the urine, was instituted. In positive cases, the worker was sent to another department of the factory. Cleaning of the hands stained with the product was effected with an alcohol and soda solution.

**LEGISLATION**

The measures come within those provided for the chemical industries. Legislation accords compensation for injury due to iodine, ethyl and methyl iodide in Switzerland. It is possible that compensation for cases of dermatitis (due to liquids, for instance) may cover also dermatitis caused by iodine and its compounds, where these disease forms have been included in the list of diseases subject to compensation without an accompanying list of the industries affected by the law in question (see article "Occupational Diseases: Definition and Compensation").
Iron, Pig Iron and Steel Industries


In siderurgy the products are classified successively into "irons", "steels" and "pig irons" according to their increasing content of carbon.

Iron, also called "soft iron", is theoretically free from carbon. Steel contains varying quantities of carbon, but not exceeding 1.50 per cent. Pig iron generally contains more than 2 per cent. of carbon.

The differentiation of iron and steel is often difficult if regard is had only to the carbon present. In ordinary language, steel is the metal obtained by fusion, and iron by welding the mass when in a pasty condition.

The "special pig irons" and the "special steels" are alloys of iron with metals such as nickel, chromium, manganese, silicon, tungsten, etc.

Iron ores are either oxides or carbonates, sometimes also iron pyrites (sulphides) oxidised by roasting to extract the sulphur. The ore is rarely pure. Mingled with it are clayey or calcareous substances, to eliminate which fluxes of varying kind are added according to the nature of the ore, calcium carbonate or dolomite (limestone) if clay predominates: siliceous matters (clays) if the ore is calcareous. Slag is the gangue which has undergone fusion.

The production of pig iron and steel in the most important countries is as follows (monthly mean in thousands of metric tons):

<table>
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<tr>
<th>Year</th>
<th>Germany</th>
<th>Belgium</th>
<th>France</th>
<th>Great Britain</th>
<th>Soviet Russia</th>
<th>United States</th>
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<td>1923</td>
<td></td>
<td></td>
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<tr>
<td>Pig iron</td>
<td>412</td>
<td>179</td>
<td>456</td>
<td>610</td>
<td>32</td>
<td>3.417</td>
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<tr>
<td>Steel</td>
<td>525</td>
<td></td>
<td>442</td>
<td>718</td>
<td>60</td>
<td>3.682</td>
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<td>1924</td>
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<tr>
<td>Pig iron</td>
<td>651</td>
<td>284</td>
<td>641</td>
<td>600</td>
<td>63</td>
<td>2.650</td>
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<td>Steel</td>
<td>829</td>
<td>258</td>
<td>575</td>
<td>606</td>
<td>95</td>
<td>3.117</td>
</tr>
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<td>1925</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Pig iron</td>
<td>848</td>
<td>212</td>
<td>706</td>
<td>558</td>
<td>129</td>
<td>3.108</td>
</tr>
<tr>
<td>Steel</td>
<td>1.018</td>
<td>201</td>
<td>618</td>
<td>696</td>
<td>179</td>
<td>3.741</td>
</tr>
</tbody>
</table>

Industrial Processes

Preparation of the minerals.— Some ores are washed to get rid of adhering earth. Others are broken up either with a hammer or mechanical crusher. Others again undergo a roasting process which frees them of sulphur and arsenic.

The mixture of ore and flux is appropriately called "the fusion bed".

Principle underlying the manufacture.— Reduction of iron oxide by means of carbon monoxide given off by the fuel used: Fe₂O₃ + 3 CO = 2 Fe + 3 CO₂. In the old process (Catalan) the temperature never became high enough to fuse the metal and ore nor to make the carbon combine with the iron. The mass remained in a pasty state and a "soft iron" was obtained after removal of the dross with the hammer. In modern processes the blast furnace is used.

The blast furnace is a lofty erection (15 to 20 metres and more), of which a cross section looks like two cones superposed on their wide bases. It is lined inside with very refractory bricks and the outside masonry is strengthened with iron hoops. The essential parts of a blast furnace from above downwards are: the mouth, the shaft, the belly, the boshes, the hearth, the crucible.

It is set going in the following way: heating up of the structure from a hearth, the base of which is made of dry wood and shavings with coke on top as far as to the mouth. When the heat is sufficient, successive layers of coke and ore are charged in through the mouth, diminishing gradually the proportion of coke until the necessary proportion for normal working is obtained. From then onwards coke and ore are charged alternately; working is not stopped except when repairs are necessary.

The molten metal and slag lie superposed in the crucible according to their density. When the crucible is full of pig iron the furnace is tapped by making an opening in the lower part. The iron, as the case may be, is run into ladles placed on wagons or into sand channels where it solidifies, to be subsequently broken up into pieces known as pigs. Tapping of the slag is done from time to time from an opening situated in the upper part of
the crucible and received into cold water which breaks it up into granules.

Normal working of a blast furnace is only possible thanks to the insufflation into the mass of considerable quantities of air to furnish the oxygen necessary for the reactions. This air, driven by a blowing machine, enters at the lower part of the hearth and rises up towards the mouth.

The principal chemical changes taking place in a blast furnace are as follows: at the point of entry of the tuyers into the hearth and lower part of the boshes (temperature of fusion: reddish white) CO is formed by the burning of the coke (C+O₂=CO₂).

At the upper part of the boshes (bright red) decomposition of the limestone into lime and carbonic acid gas takes place (CaCO₃=CaO+CO₂) (formation of slag).

At the bottom of the shaft (bright red) conversion of carbonic acid gas into carbon monoxide: CO₂+C=2 CO.

In the middle part of the shaft (red) reduction of the ore by carbon monoxide: Fe₂O₃+3 CO=3 CO₂. Further, part of the ore is reduced under the combined action of the carbon and hydrogen derived from the decomposition of the steam. In the upper part of the shaft (dull red) part of the carbonic acid gas breaks up to form carbon dioxide and carbon: 2 CO=CO₂+C. It should be noted that in the hearth near the tuyers cyanides are sometimes formed by the action of nitrogen which are partly, varying with the more or less good working of the blast furnace, the quality of the ore and fuel, etc. On the average the proportions of the different gases making up the mixture are as follows:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>15-30</td>
</tr>
<tr>
<td>CO₂</td>
<td>12-18</td>
</tr>
<tr>
<td>N</td>
<td>50-60</td>
</tr>
<tr>
<td>H</td>
<td>1-2</td>
</tr>
<tr>
<td>Steam</td>
<td>7-10</td>
</tr>
</tbody>
</table>

These gases have a high temperature and considerable value for fuel purposes. This is why they are now caught in the upper part of the blast furnace and utilised in regenerative furnaces.

Recovery. — Originally the gases captured near the mouth were used exclusively in the recuperators. The way in which the recuperators work is as follows. The gases — more or less freed, during their passage through the downcomers, of the dust which they bring with them — are mixed with outside air and enter into combustion in firebrick checkered baffle chambers within which they circulate before reaching the chimney stack. When the walls of these checkered chambers have reached a high enough temperature, the stream of gas is stopped and a current set up in the opposite direction so as to drive the heated air towards the tuyers feeding the blast furnaces.

This alternation requires, therefore, at least two recuperators per blast furnace. There are different types, the commonest being the "Cowper" and the "Whitwell".

The utilisation and purification of the blast furnace gases has been more and more perfected in recent years. A part only of these gases is used for heating the recuperators and steam boilers. The other part, used for driving the gas motors, requires more thorough purification.

First purification. — After the heaviest dust has been deposited in the downcomers, the gas passes through apparatus with a view to cooling it by contact with finely divided water, either in the form of rain (Zschocke apparatus) or in the form of humidifiers made of wire gauze (Bian apparatus). Centrifugal fans then free the gas of the dust rendered heavy by the water. In this state the gas is sent to the "Cowper" recuperator and to the boilers. It still contains from 0.3 to 0.5 grm. of dust per cubic metre.

Second purification. — The part of the gas intended for driving motors undergoes a second purification. Theissen's apparatus, which is that most used, depends on rapidly rotating paddies setting up a contrary movement of air. The humidified dust, thus rendered more heavy, is thrown against the walls of the apparatus and carried away by a current of water. The gas then passes to an apparatus for separating the water and from there to the motors which it has to drive. It then contains from 0.005 to 0.02 grm. of solid matter per cubic metre.

All this makes it easy to understand how the gas pipes have become longer and longer, and have also had their joints, valves, manholes, safety valves in case of explosion — that is when escapes take place — multiplied.

The piping requires periodical cleaning. Generally, those situated in front of the point where the initial purification takes place ought to be cleaned every three months. The pipes behind it are cleaned every six months or once
a year. The gas pipes, after the second purification, may be left for two or three years without cleaning.

The product of the blast furnace is pig iron: grey pig or cast pig iron in which the carbon is in a free state; white pig or refined pig iron intended for the manufacture of iron and steel, and in which the carbon is principally in combination with the metal.

Manufacture of Iron

Principle. — Decarburation as complete as possible of the pig iron with elimination of the largest amount of foreign matters: silicon, manganese, phosphorus, etc.

In the Conet process (shallow hearth furnace), the pig iron is placed in a very refractory crucible on wood charcoal, the combustion of which is activated by the draught from a tuyer. The oxide of iron formed burns a part of the carbon, silicon and phosphorus, with the formation of very fusible silicates and phosphates. The iron, partially decarbonised, less fusible than pig iron, forms a spongy mass (bloom) which is hammered to get rid of the slag.

Puddling. — This is done in a reverberatory furnace at very high temperature.

The pig iron, with the dross and waste very rich in oxides of iron or sometimes of basic products (lime), is melted on the floor of the furnace and continually stirred with a rabble. Dross is formed which floats on the surface and is removed. Little by little the melted mass is purified and tends to solidify in a soft spongy mass which the workman fashions in “blooms” of about 50 kilos.

There are various kinds of mechanical furnaces which take the place of puddling by hand.

Shingling. — These blooms are immediately subjected to the action of a shingling hammer which drives out the still liquid slag and gives the necessary cohesion to the iron.

Manufacture of Steel

Steel is obtained either by carbonising the refined iron or in partially decarbonising the pig iron. Various processes are used.

By puddling. — This does not differ from the process described for the production of iron except in the fact that the process is stopped before total decarbonisation.

By the Bessemer process. — The liquid pig iron coming from the cupola, or mixers of the pig iron, is run into a crucible of very large size (converter) where it is subjected to intense agitation under the action of compressed air introduced at the bottom of the apparatus by several tuyers. The receptacle of thick sheet iron is lined inside with refractory bricks. It can be given a rotary movement around a horizontal axis resting on two trunnions. It is by one of these that the air pene-

![Bessemer Process Diagram]

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**Fig. 14. — Blast furnace.**

I. Mouth; II. Shaft; III. Boshes; IV. Crucible; P. Lateral pipe for gas supply.
carbon with abundant production of oxide of carbon (flame period) — the longest period; combustion of the iron with production of red fumes of oxide (period of fume) — the shortest possible.

At the last moment before tapping a certain quantity of manganese iron is added, of which the content in manganese varies with the kind of steel it is desired to obtain.

By the Thomas process. — Certain ores (minette-coltic iron ore) containing considerable quantities of phosphorus compounds can only yield, by the Bessemer process, steels containing phosphorus in injurious amount. Hence varies with the kind of steel it is desired to obtain.

By the Bessemer process. — Certain ores (minette-coltic iron ore) containing considerable quantities of phosphorus compounds can only yield, by the Bessemer process, steels containing phosphorus in injurious amount. This is due to the silica in the refractory lining, which, reacting on the phosphates formed during oxidation, decomposes them as they are made and prevents their elimination. In the Thomas process the acid lining (silicic anhydride) is replaced by a basic lining composed of a double carbonate of lime and magnesia (dolomite). Further, in this process, a certain quantity of lime is added to the charge in the converter in order to obtain a highly carbonaceous slag. (See article "Basic Slag").

The way in which the Thomas converter works does not appear to differ much from the Bessemer: the period of sparks is shorter, and after the flame period some minutes elapse (after blow) before the fume period. Lastly the bath has to be cleaned before tapping and the addition of manganese pig iron.

By the Martin-Siemens process. — The Martin-Siemens furnaces are reverberatory furnaces with low roofs. They are heated by gas from producers and have recuperators. Their function essentially is to decarbonise and purify the pig iron by melting at a high temperature (1,800°) with old iron and steel (scrap). During refining, which lasts some hours, cleaning takes place from time to time by removing from the furnace, by means of special rabbles, part of the dross which covers the molten metal. Towards the end of the process, ferro-silicon-manganese is added. Tapping is done through a tapping hole situated at the lowest part of the floor of the furnace into a mechanically carried ladle.

Mechanical means of charging exist for the Martin-Siemens furnace. Many modifications have been made in the Martin-Siemens furnace; the principal are directed either to continuous working (Talbot or Martin continuous process), or the division of the operation into two successive steps (Bertrand-Thiel process), or lastly, the rocking movement imparted to the floor of the furnace at the moment of tapping.

Process of crucible steel. — This process is reserved for steels which require to be of exceptional quality. A crucible furnace is in principle a regenerator furnace of the Martin-Siemens type with a recuperator chamber and is generally heated by produced gas. Each crucible with its charge (of 30 to 40 kg.) prepared beforehand is covered before it is laid on the floor of the furnace where refining by fusing and removal of the dross is carried out. After refining, the crucibles are withdrawn from the furnace through an opening in the roof, either by hand by means of special tongs or more usually mechanically. Tapping follows.

Steel made by the cementation process. — The principle of the process is a carbonisation in which the carbon, derived from an external source, penetrates slowly (8 to 20 days) into the metal kept at a red heat, but without being melted. This operation consists essentially in heating wrought iron bars bedded in the carbonising substance (for example, wood charcoal) in more or less fine powder (cement) in special chambers. The top of the chambers is covered with a layer of sand which is an obstacle to oxidation.

Electrical blast furnaces. — Reduction of the ore in an electrical furnace yields a pig iron prepared at a very high temperature (3,000 to 3,500° C.).

Electrical melting and refining furnaces may be classified according to the arrangement of the electrical connections into furnaces with conducting and non-conducting floors.

Furnaces with a non-conducting floor have but a poor electrical yield, giving a very troublesome bath, and are in consequence little used. Furnaces with a conducting floor are very delicate and their advantages are much discussed.

Furnaces with non-conducting floors and carbon or graphite electrodes can heat the charge either indirectly by arc (Stassano, Rennerfelt) or directly from electrodes to the metal or to the slag.

Special steels. — The manufacture of special steels is generally done at the moment of refining. For nickel steel this metal is usually added in the Martin furnace before the addition of the manganese pig iron. It is the same with silicon steel by the addition of ferrosilicon. Chrome steels, tungsten, and molybdenum steels are made in the crucible. Steels with a high proportion
of manganese are made by preference in the electric furnace.

**Manufacture of Pig Iron.**

What is called pig iron of the second melting is pig iron produced in the blast furnace and remelted either in crucibles or reverberatory furnaces, or more often in a special apparatus called a cupola.

**Cupola.** — The cupola is a deep structure of refractory masonry slightly widened from below upwards. At its lower part are two tapping holes for the pig (iron and slag) as well as tuyers for introducing air. The pig iron is charged in with the coke and lime. The lime is added to yield a fusible slag. "Scrap" iron in greater or less quantity is often added according to the kind of pig iron that it is desired to obtain.

The molten pig iron is generally received into ladles carried by hand and run into moulds either of sand or iron.

**Casting.** — Except in the case of objects manufactured in series which are run into permanent moulds, other objects — in iron — are moulded on wooden patterns by means of a more or less powdery and plastic mixture made of clayey sand with organic matter added: straw, horse dung, etc. The moulds, when ready, are left to dry where they are or are carried to the dryer before casting.

Special alloys with iron are made such as the ferrosilicous, ferromanganese, ferrochrome, etc.

After casting is finished, the iron articles are usually subjected to a process for freeing them of sand and trimming. Freeing from sand is done either by hand by means of a metal brush or mechanically. Mining is done either by cutting or grinding.

As a final operation, the moulds are destroyed and the sand distributed.

**Sources of Danger.**

Among the numerous sources of danger for iron and steel workers are: the heavy work in almost all phases of the manufacture, the excessive heat and the action of radiant heat, especially in front of certain types of furnaces; abrupt changes in temperature; discharge of hot solid particles or splashes of molten metal; dust in general and, according to the type of work, dusts with special risk attaching to them (sand, flour, starch, etc.); gases such as carbon monoxide, carbon dioxide, sulphur compounds, cyanogen, toxic lead fumes, mercury vapour, etc., and especially the gases at the blast furnaces.

Perhaps it would be well to emphasise the most important of these sources of danger:

The crushing of the ores, their charging and discharging, and generally all the preliminary operations giving rise to the production of quantities of dust. (See article "Dusts, Fumes and Smoke").

Mention only need be made of the discharge of sulphur dioxide in the roasting of iron pyrites which is irritating to the respiratory tract.

**Fig. 15.** Bessemer converter (vertical section) (according to Carre).
In American steel works the composition of this gas is said to be as follows: carbon monoxide 26 per cent., carbon dioxide 11.12, hydrogen 3.5, nitrogen 57, acetylene 0.3, methane 1, oxygen 0.2. The gas also contains arsenuretted hydrogen, sulphur dioxide, hydrocyanic acid, stibine, etc. The most dangerous places on the route run by the gas during the different phases of manufacture are shown in fig. 16 (after Rober and Hayhurst).

Engel, of Cleveland, has recently (1925) made enquiry into cases of poisoning by blast furnace gases which, according to this expert, are very frequent among those employed in steel works. The gases are inodorous, of sweetish taste, and present a greyish fume. The gases analysed by Engel contained 25 per cent, of carbon monoxide, 12 per cent, of carbon dioxide, 6 per cent, oxygen, 55 per cent, of nitrogen, and 2 per cent, of hydrogen. In the past twenty-five years he had treated 1,200 gassed workers without one fatal case or serious consequences. All the cases were acute, none chronic. Several times the same workman had been affected. When a fatal issue had occurred, it always took place at the spot where the poisoning occurred.

Under the influence of the wind, carbon monoxide escaping accidentally from apparatus can be conveyed for quite remarkable distances and then produce fatal asphyxia.

Researches made in collaboration between a mining engineer in Belgium and a medical inspector of factories showed that wet mud in the flues contained hardly any CO, but it was not so with dry dust which retains, by physical absorption and by mechanical hold, dangerous quantities of the poisonous gas. On the other hand, these muds and dusts, which give off very unpleasant smells, are said by some enquirers to contain appreciable quantities of cyanides.

On the subject poisoning other than that due to carbon monoxide, it should be remembered that cases from arsenuretted hydrogen have been described. Cyanogen compounds also can be generated under certain circumstances.

The use of cyanides in the operations of cementation ought also to be mistrusted.

Further, when the slag is tapped as it undergoes granulation, noticeable discharges of sulphur sated hydrogen gas have been observed without reckoning on the fact that the flow of slag is sometimes aided by the use of fluorides. In certain steel works, use of seawater to quench the incandescent coke gives off hydrochloric acid fumes (Elba, Italy).

From a hygienic point of view the addition of nickel, chrome, wolfram, etc., to obtain the special steels has no great importance. On the other hand, the preparation and wrongful manipulation of iron containing silicon is a cause of very serious injury to the workmen who manufacture it (see also article "Ferrosilicon").

Ferrosilicon is obtained by melting a mixture of iron ore, quartz, coke, and lime at a very high temperature in an electric furnace. The silicic acid and the iron ore are reduced by the carbon to silicon and iron respectively so that ferrosilicon is formed, of which the content in silicon may reach 80 per cent. The phosphorus and arsenic combine with the calcium. The silicon given off in the form of vapour becomes oxidised into silicic acid once it is free in the air, and it is this which is harmful to the workers. The preparation of special steels has also been the cause of manganese poisoning.

A danger happily becoming rare, in blast furnace work is that from
explosion. Another, and very common, danger is that resulting from burns in iron and steel manufacture, especially frequent at the time of tapping.

What has been said on the subject of accidents to be feared from carbon monoxide has equal force, mutatis mutandis, in the work at, and repair of, all furnaces and hearths used in siderurgy.

The workmen in charge of all kinds of converters and other apparatus for the refining of steel up to its treatment of converters and other apparatus for siderurgy. — 19.6 to 43.5. These figures greatly increase at the moment of cleaning the castings (up to 115.2 mg.) and trimming the moulds. In this department dust (coming mainly from the chimneys) and smoke (0.15 mg. to 0.25 mg. per cubic metre) even up to the roof is a characteristic phenomenon.

Four cases of subacute and chronic mercurial poisoning with one death were reported by Jordan and Barrows, in 1924, among workers at high frequency furnaces. The mercury vapour escaped from the converters and the content of mercury in the surrounding air was about 0.7 mg. per cubic metre. Another cause of mercurial poisoning is the frequent cleaning of the mercury and repairs to the discharge pipe. New models may remove this danger altogether.

Among the compounds of iron, ferrocyanide, a liquid cherry red in colour and extremely volatile, is said by some writers to be as toxic as nickel carbonyl. It was recently (1925) proposed to substitute this for lead tetraethyl. Sanchez-Girona, of Madrid, was inclined to attribute the anaemia noted in metallurgists (1922) to the presence of sulphate of iron in the blood.

Finally, the crushing and bagging of the slag is often accompanied by evolution of much very fine and penetrating dust. When it is a question of basic slag coming from dephosphorisation (Thomas slag) pneumonoconioses set up from this dust are particularly to be feared (see article "Basic Slag").

In foundries, especially where large pieces are cast, the moulds are sometimes dried by means of big braziers or wood or coke fires. The gases given off when they are burnt and the volatile evil-smelling matters emitted from the moulds reach the sheds and sometimes make the men ill.

For the rest, the drying rooms for the moulds in foundries are rarely equipped with the necessary hygienic requirements. When tapping takes place injurious fumes are generally given off. This is why in cleaning the flues immense quantities of vapour, gas and smoke are emitted from the combustion of the organic matters entering into the composition of the foundry moulds are generally, in addition to
siliceous matter which constitutes the basis (about 80 per cent.), various organic substances: oats, straw, starch, horse dung, etc.

Another danger in the foundry is that of burns; either from sparks or accidental spilling of the metal when done by hand.

Two causes of ill-health, which are frequently found in foundries, must be mentioned.

The first is that of the sand dust used in making the moulds. This is especially noticeable in distributing the sand after pouring and cleaning the moulds either by a brush or sand blast.

The second cause is that of trimming and glazing the pieces of pig iron. These operations, when done with very hard wheels (emery) are accompanied by the production of particularly injurious dust, of fine particles of metal, and of the abrasives. The action of these dusts on the respiratory tract has received the name of "industrial siderosis" (see article "Industrial Diseases: Respiratory Tract").

Further, cutting and trimming castings is one of the most dangerous operations for the eyes in view of the projection of metallic particles. Analysis of the air of iron foundries in Russia has shown that the most poisonous element present is carbon monoxide: 0.90 to 1 mg. per litre; in one case hydrocyanic acid gas (0.08 mg. per litre) besides sulphur dioxide was found (Grodzwski). In the course of another enquiry by Brujewitsch in Russian steel works, the amount of carbon monoxide were found to be very small and of no practical importance; but on the other hand, in the foundry and casting departments as much as 0.01 per cent. and even more carbon monoxide might be found.

STATISTICS

Most writers agree in considering that work in iron and steel has a prejudicial effect on the health. It is, however, necessary to bear in mind the different occupations in the industry.

According to the statistics of the Sickness Insurance Society of Leipzig, the duration of the illnesses among iron founders was as follow (figures compared with the number of days relating to 100 workmen in every profession per year equated to 1): cases of sickness, 1.5; cases of death, 0.9; sick days, 1.4; infectious diseases, 1.2; of which tuberculosis equalled 0.9; nervous diseases, 1; respiratory diseases, 1.1; circulatory diseases, 1.1; digestive diseases, 1.4; skin diseases, 1.2; diseases of the locomotor system, 1.4; external maladies, 2.3; accidents, 2.7

The comparative mortality figures of the Registrar-General in Great Britain for the years 1910-1912 for iron and steel workers and all occupied and retired males were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Respiratory diseases, non-tubercular</th>
<th>Bronchitis</th>
<th>Bronchitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>All males</td>
<td>174</td>
<td>57</td>
<td>90</td>
</tr>
<tr>
<td>Iron and steel workers</td>
<td>216</td>
<td>100</td>
<td>186</td>
</tr>
<tr>
<td>All metal workers</td>
<td>213</td>
<td>72</td>
<td>105</td>
</tr>
</tbody>
</table>

According to enquiries made by Vernon, blast furnace workers had on an average two days' sickness per year more than other steel workers; among the older workmen (forty-nine to sixty-nine years of age) the morbidity was twice as high as among the others. Respiratory and rheumatic affections came first. The mortality rate was also higher among this group than in the other classes of steel workers.

The same expert brought out also that there was about a 1 per cent. turnover among young metal and machine workers in England and 3 per cent. among the older men. Data furnished by the Iron and Steel and Kindred Trades Association, numbering in 1911 587,000 workmen, showed 537 deaths for the period 1910-1912, which corresponds to 6 per cent. The mortality from respiratory non-tubercular diseases was 65 per cent. higher than that for all males; the mortality for diseases of the circulatory system exceeds the average by 5 per cent., while that from tuberculosis is below the average by 8 per cent., that from accidents by 16 per cent., and that from "other causes" by 7 per cent. It must, however, be observed that the turnover of workmen and the change of occupation in the same factory modify the statistics at every moment and make them very obscure.

These statistics confirm the phenomenon already stated that work in steel works predisposes especially to acute respiratory maladies and in particular to pneumonia. Very hard work predisposes also to disease of the heart and blood vessels.

Vernon and Rusher, examining the sickness certificates of the Iron and Steel and Kindred Trades Association for a period of six years, were able to obtain separate figures for each occupational class. Expressed as comparative figures the mortality was 968 for casters of steel and pit workers, 790 for the puddlers, 715 for workmen charged with control of the valves and machines, 528 for workmen manufacturing white cast iron, 748 for other workmen and 723 for workers in all industries. Mortality from respiratory diseases was very high in the case of steel casters, rollermen and puddlers. The first group showed also a high mortality rate for diseases of the circulatory system.
The same figures are obtained when the morbidity data are analysed. Here again, the same classes of workers present high figures for respiratory diseases and rheumatism and the steel casters and puddlers again stand first.

According to Hope and Hanna, the number of days of incapacity for sickness per year come to 12.6 for steel workers, as against 11.9 for iron founders, and 10.2 for agricultural labourers.

An enquiry by Hayhurst, extending over a period of three years (1911-1913) in the different departments of a steel works in which the highest turnover never exceeded 15 per cent. of the total workers, revealed the following average annual values for the morbidity of the personnel employed:

<table>
<thead>
<tr>
<th>Age groups (Years)</th>
<th>Pulmonary tuberculosis</th>
<th>Apoplexy</th>
<th>Heart disease</th>
<th>Pneumonia</th>
<th>Chronic nephritis</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-34</td>
<td>55.2 (31)</td>
<td>1.1 (1.2)</td>
<td>3.6 (4.8)</td>
<td>10.9 (7.4)</td>
<td>3.4 (4)</td>
<td>98.1 (18.4)</td>
</tr>
<tr>
<td>35-44</td>
<td>90.0 (36)</td>
<td>2.8 (3.7)</td>
<td>7.9 (8.7)</td>
<td>12.2 (9.5)</td>
<td>5.5 (6.6)</td>
<td>90.9 (14.4)</td>
</tr>
<tr>
<td>45-54</td>
<td>15.3 (14.4)</td>
<td>8.8 (8.9)</td>
<td>19.3 (11.3)</td>
<td>11.0 (9.5)</td>
<td>7.0 (8.7)</td>
<td>14.0 (10.2)</td>
</tr>
<tr>
<td>55-64</td>
<td>7.9 (7.5)</td>
<td>8.5 (9.1)</td>
<td>14.7 (15.4)</td>
<td>11.2 (8.3)</td>
<td>8.4 (11.7)</td>
<td>7.1 (6.5)</td>
</tr>
</tbody>
</table>

It should be added that this enquiry was made at a very well-managed factory employing 5,602 workmen. The certificates analysed were those the workmen sent to the Mutual Insurance Society, which excluded from benefit those suffering from venereal diseases and accident.

Hayhurst found that 1,444 calls for benefit were made for illness lasting more than five days; which made an annual average of 7.2 per cent. The maladies for which the calls were made worked out as follows: respiratory diseases, 39; digestive diseases, 26; infectious diseases, 16; diseases of the joints (rheumatism and lumbo-go especially), 18; nervous diseases (especially sciatica, neuralgia, neuritis, neurasthenia), 79; diseases of the skin, 65; circulatory diseases, 63; urinary diseases (especially nephritis), 45; strains (especially hernia, heat stroke, etc.), 41; auto-intoxication and diabetes, 27; chronic maladies, 18; sense organs, 17; tumours, 11.

An enquiry made by the Mines Department as to cases of asphyxia from gas in 1918 showed 120 cases, most of them fatal, and distributed as follows: gas flues, 6; shaft furnace, 1; blast furnace (throat), 17; hot blast, 4; cleaning the boilers, 4; gas outside the boilers, 3; flies, 34; gas washing, 12; etc. The flues and piping generally are thus shown to be the most frequent place for poisoning to occur.

In the United States, from 1912 to 1923, in three works of the Illinois Steel Company employing 1,178 persons in a certain group of processes (blast furnaces, boilers, etc.), there occurred an annual average (from 1917 to 1920) of 71 severe cases of poisoning by carbon monoxide, 271 slight cases requiring medical attention, and an ill-defined number of very slight cases not requiring medical attention. These figures at any rate are lower than those shown in English statistics.

In another American works the average annual number of cases of sickness was 13.4 per cent. among the blast furnace workers as compared with 7.9 for workers in other sections.

An enquiry made by Brundage in a town in Pennsylvania in 1919 brought out the fact that influenza and pneumonia caused 50 per cent. of the sickness among metal workers. If to these are added the other respiratory diseases (bronchitis, pleurisy, tuberculosis, etc.) the percentage rises to 61. High incidence is shown, too, of statistics of cases of poisoning from carbon monoxide in blast furnace gas are given in the report of the Medical Inspector of Factories: 1917, 22 (6 fatal); 1918, 17 (2); 1919, 33 (6); 1920, 26 (5); 1921, 18 (3); 1922, 28 (4); 1923, 21 (4); 1924, 24 (1); 1925, 25 (6); 1926, 9.
hernia and infectious diseases. Rheumatism, however, is less frequent than in Great Britain.

Analysis of 4,014 accidents occurring in the course of four years (1903-1906) in the steel works at Sestri Ponente (Italy) enabled Peri to draw a series of conclusions which are still of theoretical and practical interest at the present time.

As regards their consequences the accidents could be distributed as follows: for every 1,000 accidents 979.8 were attended by total temporary invalidity; 18.9 with total temporary and partial permanent invalidity; 12.9 were fatal.

The parts of the body affected were: the head in 545. out of 1,000, in 57.5 the trunk, in 58.3 the upper limbs, in 286.7 the lower, in 54.3 the eyes, in 21.4 other parts of the body.

The accidents to symmetrical limbs and organs were distributed thus: 11.9 per 1,000 bilaterally, 543.5 the right and 444.5 the left side.

The course taken by the injury depended essentially on opportune intervention, timely operation, antiseptic treatment, daily care of the wounded part, and care taken to avoid the consequences of accidents.

The duration of incapacity from work was less than a week in 714.3 cases out of 1,000, less than a fortnight in 201.4, less than a month in 451.2, less than two months in 56.3, less than three months in 18, and more than this in 7.6 cases.

It should be remembered that in certain departments of the works where the frequency of accidents is high, this can be explained by the fact that workmen absent from illness, accident, etc., have to be replaced, so that the number of persons exposed to the risk of accident is higher than the number reckoned unless this fact is borne in mind. Further, the same workman may be the victim of several accidents. Lastly, the requirements of the industry sometimes demand an increase in the number of workmen.

Accidents were more frequent on the night shift. The actual number of accidents was almost the same as that during the day, but the number of workmen employed at night is reduced, so that the percentage affected is higher.

The frequency of accidents has been shown to be greater in the hottest months, when the workmen are obliged to work at excessive temperatures.

The number of accidents was highest on Monday or the first day of work. It was generally followed by a fall on the succeeding day or Tuesday; but the curve rose again except on the Friday (for reasons as yet unknown). This phenomenon is but a further confirmation of the curve made out by other investigations (Imbert, Pieracini and Maffei, etc.).

Peri also proved (were it necessary) that manual work causes a greater number of accidents than machine work.

The group "35-50 years" comprises the majority of unskilled labourers, the workmen in the steel works and the departments where the risk of accident is greatest; the group "51-70" is very small, and comprises the workers who are least exposed to accidents as well as being the most skilful in the avoidance of accidents.

The frequency of accident according to duration of employment in the works was:

- Per 1,000 workmen employed less than one month, 14.9; for six months, 262.8; for one year, 248.3; for one to three years, 292.4; for three to five years, 98.6; for five to seven years, 88.8; for seven to nine years, 32.1; for nine to ten years, 12.9; more than ten years, 28.4.

An investigation was made in Sweden in 1911 among iron and steel workers at Eskilstuna, where out of 57,000 inhabitants 4,000 to 5,000 are employed in the industry in question. It related to 4,233 persons, of whom 310 were women. Open cases of tuberculosis numbered 78, suspicious cases 34, tuberculosis of other organs 26. The 9 cases noted in women related to persons engaged in packing, polishing or enameling.

In men incidence was highest among the grinders of edged tools (about five times more than among other workers); it was very rare among the casters (only 1 case among 214 employed); it was rare also among the glazers with emery wheels (5 cases among 240 employed).

In 1912 an enquiry was made among 2,000 persons, of whom 1,021 were women, employed at the surface mines of Kiruna. The number of cases of tuberculosis showed 64 open, 30 suspicious and 345 affecting the glands (17.2 per 100 examined). Among the 485 adult men examined no difference was found in the various categories of workmen as regards tuberculosis. The higher percentage among women is explained by the fact that while a medical certificate is demanded for the workers, nothing prevents sound workers from bringing the tuberculous members of their family into the work in the diggings.

Pathology

The pathology of the workers in this industry is subject to the following factors: arduous fatiguing labour, dusty and hot atmosphere, etc. Naturally these conditions are not the same.
everywhere, but still at the present time bad hygienic conditions are very often found in these industries.

The radiant heat, the high temperature, and the failure of adequate ventilation favour the occurrence of quite a series of illnesses, which are more frequent in steel works and foundries than in engineering works. Specially characteristic are muscular cramps, heat stroke, anaemia, digestive troubles, precocious senile decay among persons employed a long time in the industry (Hayhurst).

The conditions of the industry demand excessive muscular work and the strain is said to be the cause of hernia and arteriosclerosis localised chiefly in the upper limbs.

Respiratory affections take the form of bronchitis, asthma, pneumonia and tuberculosis. The lesions of the respiratory tract deserve detailed examination: pneumonia due to basic slag and pulmonary siderosis.

Grinding basic slag used formerly to give rise to enormous quantities of dust in which the phosphoric acid was combined with the lime and iron. The pneumonia was attributed to the caustic action of the lime. According to Ehrhardt, in 1887-1889 a half or a quarter of the workmen in the factory were affected by the disease and some two, three or even more times in the course of the year.

The pneumonia is acute, rarely catarrhal and often complicated with pleurisy: 25 per cent. of the cases prove fatal. Enderlen (1892) demonstrated the presence of the pneumococcus. The hygienic conditions in this work have been greatly improved, but in 1908-1909 20 fatal cases of pneumonia were reported from four works employing 420 workers. Since then technical improvements have still further lessened the dust in basic slag grinding, and since then these accidents have been greatly reduced in number. Among the methods employed mention should be made of granulation of the basic slag by means of a water spray. This prevents the dust, it is true, but causes some evolution of sulphured hydrogen gas, so that good ventilation is needed.

Opitz (1920) studied the pneumonia due to basic slag and considered it not to be a specific inflammation of the lungs. The mechanical and chemical action of the dust only prepares the ground for the morbid agents. In a German factory the mortality from pneumonia was 28 per cent.; after prophylactic measures had been taken, this fell to 1.2 per cent. — a figure twenty times higher than that in other industries. Sixty German factories, employing 2,500 workmen, had a mortality of 35 workmen per year. During the war women replaced men to the extent of 20 per cent. of the total and, apart from influenza, diseases of the respiratory tract affected 36.8 per cent. of the women and 27.9 of the men (see article "Basic Slag").

Iron (oxide) dust sets up a pneumonoconiosis known under the name of siderosis. According to the composition of the iron the pulmonary lesion is more or less serious. Thus, for example, if it is a question of oxide of iron, especially sclerosis and very rarely tuberculosis of the lungs are said to occur. On the other hand, if the dust is ferric oxide or contains phosphorus,
the lesion is said to be more serious and the mortality from tuberculosis very high.

Pneumoconiosis among ironstone miners in Cumberland was studied in 1918 by Collis and in 1925 was the subject of an address by Sir Kenneth Goadby. In 1925-1926 Cronin again took up the clinical study of this lesion among 100 ironstone miners of Cumberland and North Lancashire. The dust from the ore contained 12.66 to 13.62 per cent. of silica, 2.02 to 2.38 lime, and iron in the form of sesquioxide and traces of phosphorus (0.0067). Clinical examination showed the existence of generalised pulmonary trouble in both lungs situated principally at the apices, but which does not resemble asthma, bronchitis or pneumonia. The complex symptomatology observed is quite different from that of silicosis.

Pulmonary siderosis has been closely studied by Hoek and Denet-Kravitz; but their findings can be best analysed when dealing with dust diseases (see article "Occupational Diseases: Respiratory System").

Dust, heat, handling of hot substances, etc., set up more or less severe lesions of the skin: burns, callosities, eczema, etc. Peri in 1910 described cutaneous lesions on the hands of young workers who prepare the pine ropes used in the casting of cast iron pipes. These are made with the shavings of Pinus maritima produced by machinery. The lesion, situated particularly on the palm and fingers of the right hand, is partly traumatic in origin and partly chemical; the first is explained by the rough edges of the shavings, the second by the essential pine wood oil.

Burns also are a characteristic accident of this class of worker. According to E. Gunth, they represent about 10 per cent. of the accidents reported and frequently affect the feet. Thus, for example, in the course of eleven years, of 417 burns from molten metal 144 were on the feet. But they occur also on the arms, the face and the chest, if the men work without protection to the bare chest. Gunth gives these percentages: 35 per cent. on the arms and hands; 10 per cent. the face: 20 per cent. the feet; chest, abdomen, back, each 3.4 per cent. In steel works 20 per cent. of all burns affect the corner of the eye.

Small subcutaneous haemorrhages on the skin of the face have been observed due to the violent action of calorific radiations; callosities on the hands and feet, etc.

It would obviously take too long to set out here the facts concerning the frequency of the accidents to which the workers in this industry are exposed. It will be sufficient to recall to mind the figures already quoted.

But of all ill-effects poisoning by gas, and especially by carbon monoxide, is the most important. The symptoms which are most frequently reported are headache, anaemia, indigestion, vertigo, eburnity, vomiting, cough, palpitation, sleeplessness, inexplicable fatigue, etc. The old types of blast furnaces required the presence on the gantry staging of three or four men either to charge the furnace or to watch progress. These workmen were naturally exposed to the inhalation of toxic gases and such cases were consequently very frequent. To-day technical improvements allow charging to be done automatically and the presence of a workman is only wanted for about twenty minutes in a twelve-hour shift. At the same time the workman should take the necessary measures so that in the course of repairs or of work that he is called on to do, he is not exposed to the risk of poisoning.

Cases of poisoning have also been reported from manganese, vanadium, tellurium, etc. (see these articles).

In 1920 some Dutch labourers who in rainy weather were discharging vessels carrying a cargo of "Lux" (alkaline hydrate of iron), in the form of a reddish powder intended for gas works, complained of painful points localised at the tips of the fingers. These appeared only a few hours after work was commenced and developed into a gangrenous condition. The medical examination carried out fourteen days later elicited the fact that baskets filled with the material were carried to the place of discharge. The labourers carried the baskets on their left shoulder holding the rim with the right hand. The powder passing through the clothing reached the shoulders, where similarly gangrenous points were formed. The points showed themselves generally on the middle finger of the left hand.

Among the special sense organs the eyes are particularly affected by accident and disease. In addition to cataract, choroiditis, retinitis, and conjunctivitis, due especially to the action of dust, calorific and luminous rays, special mention should be made of ocular accidents, of which siderosis of the eyeball is one of the most frequent. In certain German factories, for example, 9 per cent. of the accidents affected the eyes; in the engineering
trade a seventh of all the accidents affected the same organ and one serious accident to every 1,000 workmen has been found. Generally the left eye is most frequently affected.

Peri in 1910 described a characteristic form of palpebral conjunctivitis among the ironstone miners of the island of Elba or among those engaged in transporting the ore. The lesion was due to mechanical injury.

In 1898 Risley described a special form of partial cataract in iron workers. This cataract occupies the lower and internal section of the lens; lesions of the same sector have been found in the choroid. Mauthner has stated that this is also the place for senile cataract to be located. Schneyder, of Soleure, has found cases of cataract recently in different stages of development in casters and rollermen. The lesion is due to the molten iron when at a white heat, and when manipulated by the workman at a distance of 1.5 to 2 metres. The lesion shows itself after twenty-three to fifty years' work, but, according to the author, examination by means of suitable apparatus allowed of distinction being made between this cataract and senile cataract or other types. Cases of cataract have been described by Thompson and Cridland among puddlers; by Roberts among chainmakers; by Healy among men rolling sheet iron; Schneyder considers that the ultra-red rays of short wave length, rather than the ultra-violet rays, are the cause of the cataract.

Mechanisation and automatic working, short hours, small glory holes, the wearing of suitable glasses (made of a lower oxide of iron) against the action of the rays are the best means of prevention.

The hearing is also frequently affected. The noise (see that article) is really enormous: rhythmic, monotonous blows provoked by the tools used mingle with the noise of cranes, falls of materials, blows from hammers, mallets, engine whistling, etc.

Kober has excluded iron as a cause of siderosis of the skin; this was, however, found by Blaschk in millers (particles of iron had penetrated into the skin of the back of the hands). A pigmentation has been noted in casters, more serious lesions in workmen handling iron rich in phosphorus (lesions due to Thomas slag). Callosities and bursitis, etc., have been reported. Stigmata are mentioned in the treatises of Ramazzini and Palissier. Bateman in 1815 described a severe case of eczema which he attributed to the action of steel dust and heat.

As to the frequent and sometimes serious accidents which occur, it will suffice to say that for the great iron and steel industry regulations for diminishing the risk have been drawn up. Thus, as examples, reference may be made to the detailed measures for the prevention of accident in iron foundries, blast furnaces, puddling, at the rolls, etc., set out by the "Südwest-deutsche Eisen-Berufsgenossenschaft" of Saarbrucken (1902), of the "Schlesi-sische Eisen- und Stahl-Berufsgenossen-schaft" (1896-1901), etc.

HYGIENE

Hygienic measures must above all relate to technical organisation of the industry. All operations should, as far as possible, be carried out by mechanical and automatic arrangements, doing away consequently with hand labour. In practice, modern industry seeks to rationalise its equipment for reasons of economy: apparatus and machinery are more and more perfected day by day, and gases and vapours are generally recovered and utilised for heating, lighting and other purposes.

Emphasis should be laid on cleanliness on the premises, because it cannot be admitted, as was formerly the case, that foundries must necessarily be black and dirty.

Special attention should be paid to natural and artificial lighting by seeing that the sources of light are not hidden by machinery or part of machines and do not create troublesome and dangerous shadows.

For natural lighting, workrooms in the form of sheds are obviously the best: for artificial lighting, the amount advised or required in different regulations vary between a minimum of 6 to 27 lux (see article "Industrial Lighting").

Ventilation should be arranged in such a way that the sources of heat do not increase excessively the temperature of the shed and do not expose the workers to radiant heat. Considerable improvements have been made contemporaneously with the technical advances in siderurgy. It must be remarked, however, that the actual relative security was preceded by a period in which carbon monoxide poisonings were particularly frequent. This fact is attributable, partly at least, to the utilisation of the gas as a motive power, demanding, as has been said above, more careful purification than for gases destined for heating boilers.
This fact has led to more complicated piping, longer flues, giving rise to accidental escapes, so that the importance of cleaning them out has been increased. Further, the cooling of the gas in the process of purification has increased not only its richness but also its toxicity.

Still, it cannot be denied that considerable improvements have been introduced; thus in modern blast furnaces, charging at the gantry staging is completely automatic, suppressing radically the principal danger of asphyxiation. This is the reason why aerial piping is preferred more and more to underground, which permits not merely of relief valves, explosion outlets at various equi-distant points, and manholes, as well as of the cleaning of flues.

In this last extremely dangerous operation, methods of isolating the path in question have been improved — hydraulic safety doors, double joints, sand baths, etc. In certain works the dust in the flues is taken away by a mechanical arrangement inside connected up to a current of water with numerous taps for cleaning, and with explosion outlets at various equi-distant points.

However, despite all ingenious means, it is still necessary from time to time to enter the flues either to carry out repairs or to rid them of the very hard and adherent deposits which form in them.

The principal precautions to be taken on entering flues are:

1. Proper isolation of the portion entered. — All the means used with this object cannot here be indicated in detail, as they vary from one factory to another; but it may be recalled that a single separator is not to be trusted. In this respect even hydraulic joints may fail: it is advisable then to double the means of closing.

2. Rational ventilation of the portion of flue visited with control of this ventilation. — It is dangerous, as is often done, to rely solely on simply opening the closing plates to ventilate the flues; it is absolutely indispensable to evacuate the heavy gases by a current of air sweeping through the flue. The method of effecting this ventilation will depend on local circumstances. It is a matter for the engineers of the section to do the best they can with the means at their disposal. After a sufficient time has elapsed to allow of the removal of the gases steps must be taken to test the air in the flues.

3. Organisation of the work and means of rescue. — The presence of a competent technical foreman is indispensable at the moment when men enter the flues and during all the time that the job lasts.

No man ought to be allowed to work alone; each member of the gang must be provided with a safety belt and rope, the free end of which is entrusted to mates outside. The manholes and openings to get rid of the gas should be numerous; an excellent plan is to arrange them so that the manholes in the upper part of the flue alternate with the openings for the removal of dust in the lower part. Lastly it is indispensable to be certain of the sound working condition of the rescue apparatus which must be kept quite close by.

In modern steel works and rolling mills the equipment has been so much improved as to reduce considerably the fatigue and dangers: charging and quasi-automatic control of the converters and retorts, puddling furnaces mechanically moved and heated by gas, stripping and mechanical transport of ingots, movement of the rolls of grooved iron controlled from a distance.

For a large number of workmen provision of clothing to protect them against burns from sparks is to be recommended: asbestos gloves, fire-proof aprons, sabots strengthened stockings, etc. Protection against radiant heat and protection of sight still leave much to be desired; emphasis must be laid on general arrangements (screens, solid or of close metal gauze) rather than on personal protection which to a great extent is still necessary from time to time to enter the flues.

The screen may be moved before the fire. These screens are sometimes watered with running water.

Among personal means of protection, goggles should be mentioned. It must be recognised that to have to wear them constantly is very disagreeable; before the furnace fire they ought not to have to be worn for more than a short time and in unusual conditions, when it is radically impossible to replace them by transparent screens (see article "Goggles").

Notable improvements have also been made in large foundries diminishing considerably the causes of insalubrity. In this connection mechanical casting of pieces in series should be referred to. This renders unnecessary the
awkward positions in which the body has had to be maintained which accounted for considerable fatigue among the casters. An objection, however, to this mechanical system of casting is the shaking and intense noise that it produces, which in themselves constitute a cause of fatigue.

Scouring of large objects is effected like ordinary cleaning by means of the sand blast in closed chambers, and this constitutes definite progress in the effort to combat pneumonoconioses.

For removing the sand from small castings use of a helmet with supply of fresh air under slight pressure is highly commendable. Where they are castings use of a helmet with supply of fresh air under slight pressure is highly commendable. Where they are

constitute, where they are mechanical grids for removal of sand constitute, where they are used, an improvement not without value.

Similarly, substitution of gravel for the sand generally used is a happy innovation reducing notably the amount of dust.

The prevention of accidents, organised on the lines of modern technical principles, allows of marked reduction in the frequency and gravity of the lesions. Thus, for example, in the United States over a period of twelve years the number of accidents has been reduced from 270 to 115, and by making the men wear protective clothing the number of burns has been reduced by 30 per cent.

The American Steel and Wire Corporation has been concerned for a number of years with the safety of its workmen (numbering about 5,000) and has organised a medical service with a hospital, where the victims receive competent treatment from a trained staff. The Corporation also from time to time organises lectures at which workmen from different departments of the works assist and are made aware of the best methods available for preventing accidents. A safety committee has been created which includes three workmen. The following figures show the excellence of this organisation:

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of accidents</th>
<th>Number of days lost</th>
<th>Number of days lost per 100 workmen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1917</td>
<td>334</td>
<td>7,491</td>
<td>5.71</td>
</tr>
<tr>
<td>1918</td>
<td>149</td>
<td>7,409</td>
<td>2.77</td>
</tr>
<tr>
<td>1919</td>
<td>100</td>
<td>6,068</td>
<td>2.17</td>
</tr>
<tr>
<td>1920</td>
<td>115</td>
<td>5,511</td>
<td>2.38</td>
</tr>
<tr>
<td>1921</td>
<td>75</td>
<td>6,003</td>
<td>2.13</td>
</tr>
<tr>
<td>1922</td>
<td>97</td>
<td>6,857</td>
<td>2.82</td>
</tr>
<tr>
<td>1923</td>
<td>68</td>
<td>4,831</td>
<td>1.64</td>
</tr>
<tr>
<td>1924</td>
<td>57</td>
<td>4,067</td>
<td>1.47</td>
</tr>
</tbody>
</table>

While the number of accidents has fallen by 83 per cent. since 1917 and the number of lost days by 47 per cent. the fall relates to slight accidents. But the duration of incapacity for each case has changed from 22.4 days in 1917 to 70.3 in 1924, which shows greater severity of the accidents.

According to Peri, prevention of accidents rationally organised can effect striking results in practice. Actually he has been able to reduce the number of accidents by arranging for strict initial medical examination of applicants; adequate selection of workmen to be employed in the departments where the risk is high; substitution wherever possible of mechanical for hand work; in controlling the use individually of measures of prevention prescribed by the management; in awarding prizes to persons collaborating in the prevention of accidents while at work; in discharging persons who show themselves unsuited to the occupation; by diminishing as much as possible excessive turnover of workmen especially at certain times of the year.

Naturally, washing accommodation, baths and sanitary conveniences should be provided, corresponding with the requirements of modern hygiene (see article "Personal Hygiene").

LEGISLATION

Among the many restrictions on the employment of women, young persons and children in the iron industries, the following are cited:

Women are prohibited from processes and industries in which poisons or fumes and dusts are given off in France (roasting sulphur containing ores, when the gases are not condensed, and the ores contain arsenic, pickling and galvanising iron, evolution of fumes and manipulation of acid).

Young persons of less than sixteen years of age are prohibited in Belgium from working in galvanising works for iron and cast iron (pickling and galvanising); boys of less than sixteen years, in the province of Quebec from picking iron by means of acid, from galvanising iron, and from the manipulation and packing of iron oxide; in Spain, from the refining of iron (places where fumes are given off and where acids are handled), and from galvanising; boys of less than fifteen in Italy from the mechanical preparation of the minerals; in Japan from work giving off much dust in mineral and metal industries; boys of less than eighteen in France are in the same category as women. Girls of less than eighteen are excluded from work in the province of Quebec (as are boys of less than sixteen); young women under twenty-one years of age in Spain, in Italy and in Japan (as in the case of boys), etc.

Health Regulations dated 30 October 1919 which apply to foundries, were issued by Royal Decree in Norway; by the Union of
Socialist Soviet Republics (Regulations of 22 July 1920 on safety rules for rollermen, 15 November 1920 on cold working of metals, 25 April 1921 applying to copper and iron foundries, and 23 December 1921 on work at forges).

Detailed regulations for iron foundries and engineering works are in force in Denmark (31 August 1906). They deal with the height of the sheds from the ground, natural and artificial lighting, cleanliness, cleaning of machinery, use of special rags when handling white lead, red lead, etc., cubic space, ventilation, meal rooms, sanitary conveniences, etc.

A Welfare Order was enacted in Great Britain, dated 12 October 1917, for the prevention of first aid and ambulance arrangements in blast furnaces, iron foundries and engineering works.

Health Regulations for the iron and steel industries are dealt with in the Labour Act of the State of Jalisco (Mexico) dated 13 August 1923 (sections 205 et seq).

The British Welfare Order applying to the tin plate industry is dated 1917 (No. 1035), and that for galvanising works, etc., 1921 (No. 2032).

Legislation also has often been enacted as regards employment of male young persons in night or foundries, etc., for vocational training, weekly rest, hours of work (eight hours), annual holiday, etc.

It would be too difficult to give an account of all existing legislative measures in all branches.

Obligatory notification is required in the Netherlands of cases of lung diseases, subcutaneous cellulitis over the joints, cataract, in persons employed in steel works, iron and other metal foundries; ulceration of the cornea and conjunctivitis in men employed in forge work.

Compensation for cataract is provided for by British and Russian law; and for siderosis in Argentina. Periodic medical examination (monthly) is required by the German Regulations applying to basic slag works (see that article).

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Figs. 14 and 15 are taken from *Carre's Industrial Chemistry*, and Fig. 17 from a report of the Medical Inspectors of Factories in the Netherlands.

*Dr. Gilbert* (Brussels).

**Iron Carbonyl**


Iron pentacarbonyl Fe(CO)$_5$, discovered in 1801 by Mond, Lauger and Quincke is in the form of an amber or reddish brown coloured oily liquid which boils at 102-103°C, solidifying at 20°C in yellow crystals. It is insoluble in water and can be mixed with most solvents. Its ignition point is 34-35°C.

It is obtained by directing a current of carbon monoxide or mixture rich in carbon monoxide on to metallic iron in a fine subdivision, at a pressure of at least 50 atmospheres and at a suitable temperature (between 100° and 200° C.). The formation of iron carbonyl is accelerated by catalysts (oxides of aluminium, of bismuth and of nickel).

Stable when kept in a closed vessel protected from the light, iron carbonyl decomposes when exposed to direct sunlight, giving iron monocarbonyl Fe$_2$(CO)$_5$ and carbon monoxide. This decomposition can be prevented by adding an azo dye.

Recently (1926) it was proposed that iron carbonyl should be substituted for lead tetra-ethyl. In fact there is on the market already an anti-detonating product under the name of "Motaline," which is a mixture of equal volumes of iron carbonyl and of petrol and which wholesale manufacturers use for preparing "Motaline," that is, motor spirit containing 0.2-0.25 volumes per cent. of iron carbonyl (4 litres per 1,000 of spirit). "Motaline" is said to be without danger, for it only ignites when it falls on a hot substance. Escape gases from motors using Motaline is said to be non-toxic, for iron carbonyl in burning gives carbon dioxide and oxide of iron.

The danger from spontaneous ignition of iron carbonyl fumes can be prevented by adding to the liquid a small quantity of hydrocarbons.
Considerable amounts have been manipulated during a period of fifteen months without symptoms of poisoning. Certain authorities, however (Kisskalt, Oliver), consider the product to be toxic and hold that it produces the same symptoms as nickel carbonyl. Cases of occupational poisoning have not however been met with so far.

**BIBLIOGRAPHY**


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**Ironing**


The material necessary for ironing consists in irons, furnaces or heating apparatus, tables and boards, as well as various accessories (grids, iron stands, rags, spatulae, marking stamps, various receptacles, etc.). The irons most usually employed are oval or round in form, with varying dimensions. As heating apparatus there may be used simple cooking stoves or special furnaces having a cover worked by weights in counterpoise, and drawers for the wood or coal. In certain cases types heated by electricity are used. In large establishments ironing is done mechanically by placing the articles to be ironed (linen, sheets, blouses, dresses, lace, curtains, etc.) either on a board covered with felt, up and down which there passes a compressing cylinder of heated metal, or in a special machine which is steam-heated.

Where the articles in question do not require very particular ironing they are simply subjected to calendering.

Ironing properly so called is preceded by damping of the articles to be ironed and in certain cases by dressing, which includes starching, or less frequently gumming (embroidered silks, fine laces, etc.).

**PATHOLOGY**

The pathology of ironers varies greatly from one establishment to another in accordance with the more or less up-to-date plant and material used. While in certain workshops conditions of work are still fairly primitive and constitute a real health risk, there exist side by side others in which use of mechanical processes and the introduction of electricity have rendered the work almost harmless, so to speak. It is with this fact well in mind that there is given below the various occupational risks which ironing may involve.

It should first of all be noted that the workrooms themselves may leave much to be desired from a hygienic point of view: workrooms encumbered with an undue amount of material (very often the linen is suspended from pulleys or ropes attached to the ceiling), dark workrooms situated in the basement (Lehmann) which are often badly lighted and badly ventilated. The vitiated air often contains carbon monoxide. According to an American enquiry referred to by Koher and Hayhurst and which comprised 244 workrooms, the analyses of the air revealed in the atmosphere near the ironers 55.4 per cent. of carbon monoxide per million parts of air, whilst near the windows the rate did not exceed 7.4. In 30 per cent. of the workrooms in question a smell of gas was perceptible. The heating of the irons was effected by gas in 50 per cent. of the workrooms. In 41.8 per cent. there was used a mixture of gas and air under pressure. Electric irons were used in 2.4 per cent. of the workrooms. Willesik and Martindale found in a workroom using gas irons from 0.3 to 0.8 and even 1.4 cub. cm. of carbon monoxide per 10 litres of air and 12-24 cub. cm. of carbon dioxide.

Thus, as has been found to be the case for various industries, the risk from carbon monoxide poisoning is greater in ironing establishments where producer gas is used. It is for this reason that its use has now been abandoned. Carbon monoxide poisoning amongst ironers is therefore not to be desired from a hygienic point of view: workrooms encumbered with an undue amount of material (very often the linen is suspended from pulleys or ropes attached to the ceiling), dark workrooms situated in the basement (Lehmann) which are often badly lighted and badly ventilated. The vitiated air often contains carbon monoxide. One day, however, on which the ventilation system was working badly, twelve women workers showed symptoms of acute poisoning by carbon monoxide. The troubles were attributed to the gas used, which was thereafter replaced by lighting gas. The latter is, moreover, not quite harmless, for on several occasions cases have been reported of carbon monoxide poisoning amongst women engaged in ironing. Since the war (1914-1918) there have been reported in the Netherlands six cases due to the use of badly constructed irons which caused liberation of lighting gas with incomplete combustion. The victims, aged eighteen to forty-three,
presented the following symptoms: headaches, somnolence, loss of consciousness (in three cases) and pain between the ribs (in one case). It is only necessary to read the medical press in order to find mention of numerous cases similar to these. The action of the vitiated atmosphere is also manifested by the occurrence of anaemia amongst those exposed to it, and Willesik and Martindale report that in the case of one-quartermaster of the workers in an ironing establishment there was found a diminution of about 10 per cent. of the normal rate of haemoglobin.

In other cases poisoning has been found to be due to various other toxic products. There should here be recalled cases due to volatile compounds of arsenic given off from coke furnaces (Lehmann, Kohler, and Hayhurst). The cases reported by an English Committee in 1901, and which affected persons working in an ironing establishment, presented symptoms consisting in vomiting, weakness in the legs and a case of complete paralysis of the legs with paraesthesia and suppression of the plantar and rotular reflexes. There were no skin troubles. In this case analysis led to the detection, not of carbon monoxide, but of considerable quantities of sulphur dioxide.

The presence of the latter caused the investigator to make tests for the presence of arsenic, which he found in a proportion of 0.001 per cent. Arsenic was also detected in the urine of two of the victims most gravely affected. Ironers who use irons heated by coal may show symptoms due to the action of coal dust (Leymann, Lewin).

Other diseases observed amongst ironers are more usually attributed to work executed in a standing position, to the special posture of ironers and to the posture required particularly by certain operations (the ironing of starched articles and of men's garments, etc.): varicose veins, flat foot, gynaecological troubles, digestive disarrangement, slight burns. Occupational stigmata (callosities) have been described on the palm of the right hand and on the fingers as a result of the pressure exercised on the iron. Codet-Boisse considers a special deformation of the wrist joint to be a result of this pressure — slight dislocation in bayonet form (known under the name of "Madelung's deformation").

The usage of an iron for hours at a time for polishing men's garments, shirts, collars, etc., causes dorsal flexion of the hands at the wrist joint which may lead to compression of the epiphysis of the radius.

There has been reported besides, especially amongst young women engaged in ironing, loosening of the wrist joint which causes slight simple dislocation in without alteration of the bones, inflammation of the tendons, accompanied by pain spreading from the thumb to the middle of the dorsal region of the forearm, a sensation of heaviness in the fingers associated at times with a feeling of stiffness of the arm and occurring especially during the night, and ceasing on the commencement of work. Finally, atrophy in the terminal region of the radial nerve may occur (Kron).

In Great Britain an enquiry carried out in 1926 relative to lesions and deformations of the hand amongst ironers engaged in marking stockings with electric irons provided the following data. The operation in question was slightly different from ordinary ironing by reason of the fact that the iron had to be lifted after each movement, and that a balancing movement had to be imparted to it. Each worker completed about 750 stockings per day. After the day's work blisters formed at the level of the top of the metacarpal joint, especially of the little finger. In six or seven weeks they hardened and at the end of two years there occurred a hardened state of the palm of the hand, especially at the level above referred to. At times the tendon flex of the small finger appeared to be implicated, for complete extension was inhibited. In the case of workers with a long record (six years or over) there occurred deformation recalling Dupuytren's contraction. After cessation of work the skin reassumes its normal aspect. Nevertheless, slight contraction of the flexion of the small finger has been noted in the case of a worker after resting for nine months.

Hygiene

The workroom should be spacious, well lit and well ventilated. The ironing tables must be broad and fairly high in order that the worker is not obliged to bend more than necessary. There is also recommended the use of holders made of soft cloth, which is a bad conductor, in order to diminish the effect of hard pressure and excessive perspiration of the hands. Cast-iron furnaces should be subject to control with a view to avoiding diffusion of toxic gases (carbon monoxide) in the workroom. As a general rule the damper should never be completely closed. Gas furnaces should be placed under a chimney with a good draught.
and any vitiation of the atmosphere should be combated by an adequate ventilation system. Artificial light should be electric with a view to complete elimination of the risk from the escape of toxic gases. The same should be the case with regard to the heating apparatus wherever it is possible.

Women ironers should take requisite precautions to avoid chills (from abundant perspiration and exposure to draughts) by wearing wool or flannel next the skin. Occupational deformations should be corrected by requisite gymnastic exercises. Blisters forming the initial stage of callosities should not be burst, as this leads to risk of subsequent infection.

Peripheral paralysis occurring amongst women ironers is subject to compulsory notification in the Netherlands. Chronic teno-synovitis is compensated in the U.S.S.R.

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Ivory


Ivory, which is got from the tusks of African and Indian elephants, is shown on section to be formed of concentric layers. Old tusks often contain cracks, which are filled in by mineral mastics. It is yellow in colour when taken from young or adult animals, becoming greenish in the case of aged animals.

Besides elephant tusks, there are sometimes utilised those of hippopotami, walruses and narwhals, etc.

Ivory is used in the manufacture of various objects (billiard balls, frames for fans, piano keys, small objects of furniture and sculpture, etc.). The powder and the debris are used in the manufacture of artificial ivory (by agglomeration) or in the manufacture of animal charcoal.

Ivory, cut into pieces of varying size according to the objects to be manufactured, may be encrusted with dirt and more or less covered with fat. Under such circumstances, it has first to be treated chemically, and thereafter placed in a hot alkaline bath, followed by plunging into cold water. Where necessary, it is bleached by means of peroxide of hydrogen or sulphuric acid with sodium peroxide. All requisite precautions require to be taken in the course of these operations.

For the manufacture of certain articles, the ivory requires to be tinted. Where it is necessary to achieve penetration of the product into the interior of the ivory, after passing through an alkaline bath and washing, it is plunged into a very slightly acidulated bath of nitric acid in order to remove the external scale and expose the cartilaginous part. It is then rinsed thoroughly in cold water, and thereafter submitted to the dyeing process. It must not be plunged into hot water, as this would cause cracks in the ivory, or at least, where this is done, it must be immediately thereafter placed in cold water. Manipulation of ivory is similar to that followed in regard to bone in the bones industry (see that article).

Artificial ivory is manufactured either with the debris from ivory agglomerated by the use of glues and appropriate mineral substances, or by substances having a similar aspect to ivory (cellulose, galalith, etc.). For the manufacture of animal charcoal, see article "Bones Industry".

Sources of risk are almost exclusively confined to liberation of dust, which may be avoided by executing cutting and sawing of the plates by the damp method and by providing adequate ventilation over the grindstones and cutting machines so as to prevent the dust being disseminated in the atmosphere (see article "Bones Industry").

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Jewellery Industry


Gold and platinum cannot be said to possess interest from the standpoint of industrial poisons. Silver is not a toxic metal, but absorption of silver compounds may give rise to argyria (see article "Silver").

INDUSTRIAL OPERATIONS

Goldsmiths' and silversmiths' work comprises a large number of operations, including melting, casting, forging, rolling, presssing, filing, planing, polishing, soldering, welding, galvanising, engraving, engine turning, and chiselling. These operations are mostly effected in a sitting position and are partly machine and partly hand work.

In factories for refining precious metals silver mixed with copper, melted, cast and mixed with water in granulated form is dissolved in sulphuric acid. After decantation the silver is precipitated by the copper and the silver thus obtained is thereafter melted.

Gold is treated with hot concentrated sulphuric acid which dissolves silver. The gold powder obtained is washed and melted; the silver which the gold may contain remains in the mother liquor and is precipitated by the copper.

Platinum dissolved in aqua regia is precipitated by alkaline salts and thereafter melted.

Goldsmiths and jewellers use gold and silver ingots, or mostly metal in sheets, plates or leaf, etc. For the making of "flat stock", bars of gold are sweated by means of silver solder on to bars of brass of the same width in a gas furnace giving firm fusion.

Plated gold and silver are prepared by means of copper foil lined with silver or gold foil, adherence being effected without welding by rolling red hot.

Where only a few copies of the articles manufactured are required the processes followed by the goldsmith are very variable: round or oval articles are turned; others are cast in moulds — they are stamped in a press or planished with a hammer. The different parts of an article are assembled and finally welded together.

Decoration consists of carving, chasing or chiselling (in the case of cast ornaments), engraving, polishing, etching, incrustation, enamelling, etc.

On the other hand, for articles to be turned out in quantity cutting out and stamping is done by rolling in matrix cylinders with hollow engraving which effects automatic engraving, engine turning, etc.

Table cutlery is manufactured by rolling in matrix cylinders or by stamping in a press. The work is finished off with a file, then silvered over by a galvanoplastic process (silvering) or gilded with vermeil. Polishing is done on a lathe provided with a brush and by applying putty powder. As polishing substance there may also be used "polishing red" or colcothar, pumice stone ground in oil, tripoli, etc.

After polishing with putty powder a special brilliancy is imparted to the polished article (burnishing) by means of revolving discs provided with buffing leathers impregnated with colcothar, or Viennese calcium dissolved in olein. The dust from the polishing wheels is collected under water in tanks which serve for the ultimate recovery of gold and silver.

Enamelling of precious metals is effected by use of vitrifiable colours dissolved in water which are baked in an enamelling furnace (or muffle furnace). Enamelling of small objects is done by blowpipe, polishing being effected by the use of rottenstone or putty. The latter operation may expose
the workers to the risk of lead poisoning (Tula enamel; see article “Silver”).

The jeweller engages in goldsmiths' work and also in that of making jewellery, for he handles both precious metals and precious stones. His work, however, is finer and more delicate than that of the former, the objects handled being of smaller dimension. In connection with the making of fancy jewellery there now exists an extensive industry of imitation jewellery. Precious stones are replaced by false stones, pearls by false pearls, and gold by copper gilded by the mercury process or by plating processes. Another branch of the industry is devoted to plated jewellery, gold and silver plated leaf, etc.

The floors of the workrooms are usually made of polished brick covered with wooden lattice work to prevent the dust being carried away by the workers' feet.

DANGERS

During the operations of melting, the workers exposed to radiant heat from the crucibles become subject to forms of eczema, particularly when persons of undue susceptibility are involved. The operations of moulding and stamping demand very considerable muscular effort, and involve the risk of shocks which in the case of certain individuals have fairly serious results. Stamping and polishing are equally trying, especially when the manufacture of silver articles is in question. Where foot machines are used affections of the abdominal organs and haemorrhage have been noted among women workers. Hand work also has been known to give rise to urinary paralysis.

Soldering may also be regarded as trying work where the heat source is defective and the use of the blower has often to be resorted to. It happens fairly frequently, especially in technical schools, that the same blower is used by various persons; in this event the same well-known disadvantage met with in the work of glass blowers is involved; the mouthpiece therefore ought to be the personal property of each individual, or, better still, a compressed air blower should be used.

The use of soldering lamps exposes workers to the harmful action of combustion gases, especially carbon monoxide, particularly where work is effected in confined quarters. The action of toxic fumes given off by molten metals, acid solutions, and electrolyte baths must also be recalled. Amongst such metals account must be taken chiefly of lead and of mercury, amongst the acids, hydrochloric, nitric and sulphuric, and amongst other products liberated by the electrolytic baths particular mention should be made of prussic acid. Nitric acid mixed with hydrochloric acid is also largely used for scouring metals.

Polishing is generally done with a hot solution of caustic soda or with calcium or by means of a sand blast effected in a closed apparatus with exhaust. The chemical products used are notoriously responsible for irritation and burning or corroding of the skin and the mucous membrane.

For scouring, benzin, petrol spirit, trichlorethylene, carbon tetrachloride, etc., are used and the use of these products often causes vertigo and headaches. Zapon lacquer also gives rise to similar troubles. For this reason cleansing by electrolytic process, which is greatly superior from a hygienic point of view to the methods in actual use, has been recommended. For this purpose a solution of chloride or Glauber salts, which, under the action of the current, liberates chlorine or sulphuric acid, is used. Mention has already been made of the use of cyanides for electrolytic baths. Cases of discomfort or of poisoning may be prevented by installing good localised ventilation.

The danger from mercury poisoning common during the operation of hot gilding is now rare.

The use of ammonium sulphide for decorative purposes is often the cause of irritation and burning due to liberation of sulphuric acid.

Polishing of silver is hard work causing muscular and articular pains, especially when done by hand; it is now, however, mostly done by machinery. The cleaning of metal with beer and with Panama powder (with a basis of saponin) is also an operation in course of which the workers are exposed to irritation of the skin and mucous membrane. Finally, attention should be paid to the lighting, especially for workers engaged in engraving who require a very high-powered lighting system (200 lux), the luminous rays being concentrated on the working post by means of a globe filled with water.

Waste, dust, debris, cinders, sweepings and washing water are carefully assembled and subjected to treatment for the recovery of the precious metals. The cinders are sorted and washed and triturated in a mill with mercury; the amalgam obtained is thereafter heated in order to remove the mercury.
The mortality rate from lung diseases amongst goldsmiths in Berlin during the years 1886-1893 was 42.5 per cent., of which 40.2 per cent. represented tubercular cases. Mortality statistics collected in America for jewellers (inclusive of clock and watch repairers and gold and silver workers) for the years 1908 and 1909 showed that out of 866 deaths 122, or 17.8 per cent., were due to pulmonary tuberculosis; but this relatively low average figure, for all ages, is modified for proportionate mortality according to the divisional periods of life, which reveals the proportionate mortality from pulmonary tuberculosis at the younger ages to have been quite excessive — 50 per cent. between the ages of 15 and 24 and 29.7 per cent. between the ages of 25 and 34. The experience of an American industrial insurance company shows that of 812 deaths from all causes 39.5 per cent. were due to diseases of the lungs and respiratory passages and the conclusion of an investigation based on these figures is that jewellers are subject to a decidedly excessive mortality from pulmonary tuberculosis at ages under 45 and particularly between 15 and 24. As regards morbidity, the same results were formerly noted by Zadek amongst the jewelers of Vienna. As regards mortality he found that it was highest for the group of workers engaged on metal work — and that both as regards total mortality and mortality for the different age groups. In fact for the group 15-20 years of age the mortality was twice as high as the average mortality for all the members of the Sickness Fund for the ages in question.

PATHOLOGY

The occupations of gold and silversmiths are often chosen by workers of peculiar physique, and this partly explains the frequency of chronic afflictions of the eyes and respiratory organs and especially tubercular infection. Other lesions are derived from acid, mercurial and lead fumes, etc., given off during various operations.

Inspection in this industry has not infrequently revealed a tendency to overcrowding, and this, together with a continuous sedentary position in a stooping attitude due to the absence of adjustable seats, and an unduly high temperature constitutes injurious factors often aggravated by the presence of dust, and other adverse conditions, such as eyestrain incident to work on the various fine processes. The occurrence of visual defects is due to much of the work being done at close range and involving eyestrain in the absence of an illuminating device. Where the light source is too glaring and highly reflecting surfaces are handled irritation and ocular fatigue are caused. Emery wheels used in stone-cutting wear away quickly and give rise to the generation of a certain amount of toxic lead dust. The process of colouring gold causes the emanation of chlorine fumes, which irritate the respiratory passages. Soldering produces not only eyestrain but exposure to heat, inhalation of the products of combustion and possibly also of coal gas due to defective tubes and burners. Finger injuries are not uncommon amongst workers operating stamping and pressing machines. Attention has been called to the fact that miscarriages and premature births are of frequent occurrence amongst the women workers employed in the Pforzheim jewellery industry, and this has been attributed in some measure to the use of the foot power presses. One authority suggests, however, that the constant handling of brass goods may perhaps constitute a subtle form of lead poisoning to which the embryo is especially susceptible. A case of lead poisoning notified to the English factory inspectorate affected a woman worker employed in a workshop where medals were enamelled and who had got into the bad habit of pointing with her lips the brushes used for applying the enamel.

HYGIENE

Good exhaust systems are essential to combat the dust generated especially in the operations of filing, turning and polishing. The importance of the recovery of the metal dust from an economic standpoint usually results in this precaution being adopted; local exhausts are fixed close to the work and at the level of the work and having filler shaped orifices for catching the dust. These localised exhausts over each machine or tool are connected up by piping to a strong ventilator at low pressure. Flannel filters are inserted between the exhausts and the ventilator, causing the dust to fall into sacks or other suitable receptacles, while the air escapes outside. Both filters with automatic cleaning device are used. For operations concerned with imparting brilliance for which cotton-covered polishing buffers are used, liberating in the dust textile fibres, cleaning is not done automatically but by hand (Frois).

By reason of the great variety in the work it is advisable to ensure that a limited number of operations only be effected on each machine, which should be fitted with the hood appropriate to such operations.

Brightening (antivage) is only a
special kind of polishing calculated to impart great brilliance. It is obtained by rubbing the objects on wheels covered with cotton cloth impregnated with Viennese calcium and grease (oil) revolving at great speed. It is advantageous to provide the workers directly with prepared blocks of the chalk and oil, thoroughly mixed, which, applied to the polishing wheel, spread the chalk thereon without liberation of dust. Despite all precautions, however, a little dust is raised, and the application of hoods, as in the previous operation, is not possible, for it is essential that the workers should have free access to the lower part of the polishing wheel. Frois remarks on the possibility of enclosing the working post by a sheet metal box, leaving the lower part entirely free. Where it becomes a question of imparting brilliance to very large objects the sheet metal box would acquire such dimensions that the pressure would no longer be sufficient for withdrawing the dust blocking up the channel. It would then be possible to branch at the back of the box the pipe of a ventilator providing air at a pressure of 150 mm. of water. Emptying of the pipes is rapidly effected and the material recovered is calcined in furnaces.

The dust recovered is calcined to remove particles from the buffers and the extraneous matter and the cinders are then passed to a foundry for proper treatment by isolating compounds.

JUTE

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Prof. G. M. Kober (Washington).

Jute

French and German: Jute. — Italian: Juta.
Spanish: Yute.

GENERAL REMARKS

Jute is a textile fibre obtained from various species of the genus Corchorus growing in certain marshy regions of the tropics, but cultivated on a large scale almost exclusively in Bengal and Assam.

The fibre is found in the ligneous layer covered by the stalk. The principal ingredient of this fibre is cellulose mingled with a complex ligneous substance called lignose. For the purpose of comparison, one might say that cotton fibre consists almost entirely of pure cellulose, whilst that from flax contains about 40 per cent. of peptose, and raw jute contains 35 to 40 per cent. of lignose.

Its chemical composition allows of easy combination with basic substances, but at the same time this renders it very sensitive to the action of chemical agents such as those employed for bleaching purposes.

For this reason jute is rarely bleached right through, as carbons of soda and hypochlorite weaken the fibre too much.

When the dyeing process is reached the jute, in consequence of the processes to which it is subjected, loses about 10 to 15 per cent. of the fibre.

The qualities of jute as it is met with in commerce are very variable, especially as the place of origin.

Serajgunge is a soft jute of moderate strength easily bleached and with a tendency to produce a thread whose fibres form points or balls. Its colour varies from white to a bluish or reddish grey. Sometimes red fragments are found derived from the roots. Serajgunge Jute is grown in the basin of the Jumna.

Naratingunge is fairly stout. It is soft to the touch and readily separates into simple long fibres. It often retains earthy matter derived from the retting water. Its colour is creamy white, but the ends of the fibres are red. It is useful for making rope and weaving.

Ultraja Jute much resembles the two sorts just described, but is often of a
lower quality because of retting conducted in stagnant waters which affects its colour deleteriously. This variety comes from Haldibari, and is almost always of a pink colour.

The quality Daisee is of a soft and silken character; it is obtained from Cordia cajan fistula. It tends to be at times bright, and at times grey and brown. Its good qualities render it very suitable for spinning. It is used for the weft and the wool in weaving, where a definite colour is not indispensable.

Dowrah jute is of average strength, rough, hard, breakable and deep in colour; it is used for strong woven material such as sacking and for ordinary purposes and when used pure, or mixed, for cordage.

The fibre Bimlapatum or “Bimli” for short, is resistant, hard and short. In mixtures it is used for the weft in weaving strong material. It varies from a light to a deep grey and possesses no lustre. It is the kind most widespread and is found in different parts from India to Java. It belongs rather to a kind of hemp from Hibiscus cannabinus and is described as a bastard jute. Chittagong jute is closely allied to the varieties coming from Naraingunge and Chittagong, but is better prepared, cleaner and almost free from fibres drawn from the roots.

Lastly, Tossa resembles the better qualities of Daisee. It has a beautiful lustre, spins very well, and is suitable for fine thread where colour is not a matter of importance as it is brown.

As has been said above, almost all the jute comes from India and particularly from Bengal. The plant might be cultivated successfully in other countries where, however, the efforts have not been attended with much success as the retting processes in vogue in India are much superior.

From jute resistant materials are manufactured, especially sacking and packing materials, carpets, curtains and passementerie; or when mixed with other fibres velvet, rope soles, cord, string.

**INDUSTRIAL PROCESSES**

To obtain the jute fibres the plant is cut down immediately after it has flowered. Then it is retted, generally in running water, sometimes in stagnant water and the bark is removed by hand. The annual production is about ten or a dozen million bales, of which more than one-half is consumed locally by the factories in Bengal. Great Britain, particularly Scotland (Dundee), consumes about a million bales. The rest is worked up in Germany, in France (North), Italy (Piedmont), the United States, Japan, etc. One bale weighs 400 English pounds (about 180 kg.); but there are bales of 112-130 kg. (“cutcha”).

The jute arrives at the factories as a mass of unspun fibres, fairly long and strong, of a silky appearance and of very diverse qualities and tints as has been described. In the factories it undergoes the later changes by processes analogous to those employed in the manufacture of flax and hemp. In order, however, to give the fibres the suppleness they lack, they are oiled, i.e. impregnated at an early stage with oil.

This oiling is effected at the moment when the fibres pass through the batching machine. It is carried out in various ways according to the taste of the manufacturer and to the uses to which it is going to be put. Sometimes an oil is used which has no smell if it is a question of a jute of high quality; sometimes fish oil is used or soap solutions, etc. The quantity of oil used varies with the season of the year. For good spinning the fibres should contain from 10 to 12 per cent. of moisture.

After passage through the breaker, which divides it into strands, the jute goes to the cording machine, from which it emerges in the form of a ribbon which becomes converted into thread by passage through the roving and spinning frames. Spinning is done dry. The thread is delivered to the client not in bulk, but on reels or on cops. For some fine sorts the fibres are combed instead of being carded, but the tow which falls from the combing machines is collected and placed with the sorts which go directly to the cards.

**STATISTICS**

The statistical data available provide no morbidity or mortality returns for this class of worker exclusively, being included with returns for textile workers generally.

**PATHOLOGY**

The workmen are often incommoded by the dust arising from the manipulation of the fibres; these dusts frequently set up the syndrome (known under the name of “mill fever”) characterised by febrile attacks accompanied by violent coughing, bronchial catarrh and prostration. The particles of dust which irritate the respiratory passages are made up of bits of fibres the jagged edges of which set up marked irritation of the mucous membranes (by anaphylactic phenomena). Further, account should be taken of a chemical action due to the oil emulsion and the alkaline solutions used in oiling (Carozzi). The symptoms last two or three days and often disappear without treatment. Oliver
also states that statistics furnished by the Dundee Hospital showed a high number of cases of lobular pneumonia.

Skeletal deformities (of the legs) have also been described among jute workers, due mainly to constant standing on a continually vibrating floor. These deformities have been met with among workpeople who commence work very young, when their bones and joints are in process of development and more sensitive to the action of injurious causes (Carozzi). By others this pathological process is attributed to a sort of osteomyelitis (Klein).

As a consequence of the excessive noise in the weaving sheds and diffusion of dust in the air causing plugs of wax in the ears, deafness is common.

Hoarseness, noticeable in workers employed in the preparing and spinning room, is due to the dust and over-fatigue of the voice caused by the necessity of speaking loudly because of the noise.

Throat troubles are often associated with chronic pharyngitis especially in women and children.

The particular frequency of pharyngitis among jute workers is brought out in the following figures collected by Zambler: 65 per cent. of cases among jute spinners, 15 per cent. among jute weavers, 20 per cent. among silk spinners and 21 per cent. among domestic workers. The particular frequency of adenoid vegetations among women and children should also be mentioned (Zambler). Moreover troubles affecting the respiratory passages are also favoured by the high temperature common in the spinning rooms.

Fatal cases of tetanus among the jute workers of Dundee have been reported. The spores were found in the dust collected under the breaking machines and enquiry brought to light that they had come over in the earth attaching to the jute plant from India (Legge, 1898).

According to Hope and Hanna, jute workers are also said to be liable to diabetes. Skin affections have been described in workpeople engaged in boiling jute in alkaline baths (soap, caustic potash or soda: Prosser White). In a Dutch spinning mill where the thread was impregnated with a solution of yellow soap, impure fish oil and mineral oil, more than 50 per cent. of the 87 young women employed suffered from dermatitis (1916). This was characterised by irritation of the skin, redness and swelling, dry eczema, papillary hypertrophy and inflammation, advancing even to suppuration (Kranenburg).

The colouring matters and oils handled in manipulating jute are the cause of folliculitis observed, notably in India. The lesion is non-suppurative in character brought on by mechanical obliteration of the orifices of the subcaneous glands by debris from the corneal layer, the exfoliation of which was obstructed by the presence of the oil on the skin. The accumulation of this debris is frequent among the natives, who do not use detergent soap sufficiently, water alone being insufficient in these cases (Curjet and Acton).

Although it cannot properly be called an unhealthy industry, work in a jute factory is prejudicial to health, especially in countries where work is carried on from father to son. In such cases the children are exposed to all the unpleasant elements in the work, which ends by lowering their general resistance and affecting their growth unfavourably.

According to Oliver (1908), young girls of seventeen and eighteen years of age look as though they were thirteen; anaemia is rife, with a considerable incidence of tuberculosis among the jute workers. It is necessary, however, as for all statistics on the effects of inhaling dusts dating back for a relatively long period of time to consider the data as suspect. In the absence of bacteriological examinations such statistics include, under the designation of tuberculosis, all bronchitic, chronic and severe pulmonary affections (Agasse-Lafont).

HYGIENE

As has been said, the processes which jute undergoes in its manufacture are practically the same as those for flax (see article "Flax"). The workpeople are exposed to the same risk of dust, rather less, doubtless, in consequence of a certain moisture given to the material in the process of oiling. Naturally all kinds of jute are not equally dusty. Jute cannot be spun when wet. In the preparing and spinning rooms the relative humidity found to be most favourable is from 70) to 75 per cent. Generally a temperature of 18° C. is maintained with 70 per cent. relative humidity in the preparing rooms and 22° C. and 80 per cent. in the spinning. Artificial humidity is, therefore, necessary in the majority of rooms. (See article "Air: Hot and Humid Atmospheres").

As to the processes carried out at the place of culture — harvesting, retting, extraction of the fibres, etc. — the
workpeople are subjected to the same inconveniences as are those employed in the garnering of rice. It was thought for some time, doubtless owing to coincidence, that risks encountered in the spinning and weaving of jute would involve more serious consequences than in factories where textiles are worked, on account of tetanus, but nothing of the kind has proved to be the case.

In the process of breaking on a large scale, energetic ventilation of the workrooms should be adopted by means of fans so arranged as to direct the dust either under the furnaces or into collecting chambers. Some authorities recommend the introduction of ozone into the workrooms where jute is manipulated. Care should be taken to place the furnaces outside, to warm the rooms by means of steam pipes and to illuminate them from the outside by enclosed lamps, and to arrange the machines so as to avoid incommoding the neighbourhood by noise or vibration.

**Legislation**

In Germany young persons under eighteen years of age are prohibited from employment in rooms in which opening, batching, breaking, unravelling, oiling, mixing and removing the dust from jute are carried on (Order of 8 December 1909). Young persons under eighteen years of age and women are prohibited from work in the Netherlands, in processes preliminary to spinning if unprovided with a medical certificate (Act of 1920, section 33, subsection K, and section 35).

Boys under fifteen years of age and women under twenty-one are prohibited from work in breaking, carding and cleaning jute in Spain where there is exposure to dust. The same applies in France to young persons under eighteen years of age in large scale breaking, and in Estonia to young persons under fifteen years in jute spinning.

Special regulations for the manufacture of jute are not numerous, because generally the processes are regulated by the same restrictions as are laid down for the textile industries, and particularly for flax.

In Great Britain the Regulations of 28 August 1907 deal with spinning and weaving of hemp and jute and of hemp and jute thread and processes connected therewith (see article "Hemp Manufacture").

In India (Punjab) the Factory Regulations of 17 October 1922 state in section 23 that in every room of a jute mill in which opening bales, machine hackling, carding, preparing or other processes giving rise to dust to such an extent as to constitute a source of danger to the workers, are engaged in, efficient locally applied exhaust ventilation shall be installed as near as possible to the point of generation of the dust.

**Bibliography**


P. Boulin (Lille).
Kapok

This name, which is a Malayan word, is given to material used for stuffing upholstery, provided by the fruit of several colonial plants belonging to the family of Bombacaceae, and found chiefly in the West Indies, Indo-China, Japan, Central and South-ern America, tropical Africa, etc. The best qualities of kapok come from Java and Calcutta.

The fruit resembles a cucumber of 8 to 14 cm. in length, and when opened shows a woolly mass, the real “kapok down”, in which the seeds are quite free.

Kapok with long and silky fibres is used for filling mattresses, pillows, cushions, seats of motors, etc. For some years, thanks to carding machines which do not break the fibre like ordinary weaving machines, it has been possible to weave the kapok into cloth and to make knitted goods and various garments of it.

The great flexibility of kapok explains its utility for rescue articles (life belts, life buoys) for a weight of kapok can succeed in keeping afloat a weight 30 to 35 times heavier.

Treated with sulphuric acid and nitric acid it gives a product which, like gun-cotton, dissolves at least partially in alcohol and ether and leaves, on evaporation, a film similar to that of collodion.

The seeds of kapok are used for the oils which they contain (20 to 25 per cent.) in soap making or as substitutes for edible oils in the manufacture of margarine. The cakes are used for cattle fodder.

The fruit is gathered before it is quite dry. It is opened by hand and the kapok removed. This operation must be effected as rapidly as possible, since when left in the shell the fibres rapidly take on a colour which diminishes their value. The workers entrusted with this operation must carefully examine the quality of the fibre, eliminate that which is spoilt (mildewed) or belonging to a secondary quality (with greyish or reddish fibres). The raw kapok is generally placed in bales weighing 40 to 50 kg.

The best qualities of kapok come from Java and Calcutta.

The operations of cleaning and ginning kapok, as well as those of winnowing, are so dusty that entering a factory is like penetrating into a thick fog (Heijermans) in which a peculiar and special sensation affecting the nose and throat is experienced. There is pricking and pain in the eyes. After a certain time there occurs acclimatisation to the inhalation and to contact with the large quantities of this dust. The process of winnowing is all the more harmful since the workers who recover the kapok are immersed in it up to the shoulder while shovelling it up.

The injuries to the lungs caused by kapok are much better known since the use of X-rays has revealed amongst workers in this industry a sclerosis of the lung, whilst ordinary clinical symptoms did not show up anything of importance (Heijermans).

The hygienic measures to be taken are similar to those provided in regard to other textile fibres and in particular to cotton.

As regards legislative measures, the only one in existence is that issued in the Netherlands, which requires compulsory notification of pulmonary troubles occurring amongst workers in kapok factories. ***
Lace


General Observations

Lace can be made by hand or by machine. Hand-made lace includes:

1. Needle-point lace done with a plain needle and sheet of paper or parchment on which the pattern to be executed is reproduced by pricking. According to the way in which it is made, needle-point lace is called Venetian, Alençon, Brussels, English, etc.

2. Pillow-made lace (made with thread wound on bobbins) is done on a lace pillow or cushion (a kind of stuffed box), carrying a piece of paper on which is chalked or pricked the pattern to be executed. Pins inserted on the cushion serve as indicating points for attachment of the threads unrolled from the bobbins. Such lace is called Valencienne, Malines, Flanders, Spanish, etc.

3. Appliqué lace, filet lace, artistic guipure.

In machine-made or woven lace (Dentelle mécanique ou d'imitation, Maschinen spitze) the interlacing threads imitate the pillow-made lace on tulle (a net-like tissue with open mesh, generally of hexagonal shape). Guipure can also be made mechanically on open-work tissue for furniture, curtains, bedspreads, etc.

After their manufacture, these different kinds of lace must be washed, dried under pressure, finished, goffered, bleached, or dyed.

Pathology

In some branches of the lace industry excessive heat and moisture are found. According to Arlidge, goffering is the process most injurious to health, because it has to be done with machines heated by gas, from which there is a risk of poisoning from carbon monoxide.

Making lace from thread involves a certain risk as the hemp dust is liable to contain silica.

Mention should be made of the risk of lead poisoning among workmen charging the thread with lead acetate or who dust the lace with white lead to bleach it.

The mortality rate from tuberculosis in this industry is very high, except in Great Britain, where the death-rate from tuberculosis is below the average of the other branches of the textile industry. On the contrary, mortality from alcoholism, diseases of the liver and of the nervous and circulatory system is in excess.

Knowles (quoted by Prosser White) describes dermatitis among lace-makers probably due to acids.

According to the statistics of the Leipzig Local Sickness Society, the mortality rate in the lace industry is very low: 0.35 per cent. for men and 0.5 per cent. for women. There were 620 sickness days per 100 workmen and 910 per 100 workwomen.

An enquiry carried out in September 1923 in the "Liverce" Lace Factory of Moscow gives interesting details as to the sanitary conditions in this industry.

The personnel consisted of 600 persons, the majority of whom looked after the machines. These machines were notable for their large size (manufacture of curtains) and complicated working, which demanded sustained attention and constant eye-strain on the part of the workmen. The threads, of very fine counts, were wound upon 80 to 120 bobbins, and were lit up from behind by small electric lamps, making it necessary for the weaver to work constantly by artificial light. This very complicated work requires an apprenticeship of several years. For this reason among the personnel, composed entirely of men, there were none who were young.

The enquiry covered 43 workmen distributed in age groups as follows:

<table>
<thead>
<tr>
<th>Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 30 years</td>
<td>0</td>
</tr>
<tr>
<td>30 to 39 years</td>
<td>14</td>
</tr>
<tr>
<td>40 to 49 years</td>
<td>23</td>
</tr>
<tr>
<td>50 years and over</td>
<td>6</td>
</tr>
</tbody>
</table>
LACTIC ACID  

Two workmen only had been employed for less than two years, 24 from five to nineteen years, 11 from twenty to twenty-nine, and 6 for thirty years or more.

The medical examination of these workmen gave the following results:

<table>
<thead>
<tr>
<th>Disease</th>
<th>Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuberculosis, diagnosed or suspected</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>Chronic rhinitis</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>Chronic bronchitis</td>
<td>14</td>
<td>33.5</td>
</tr>
</tbody>
</table>

The two last affections might have been attributed to inhalation of graphite dust with which certain parts of the machinery had to be powdered.

The eye diseases were distributed as follows:

<table>
<thead>
<tr>
<th>Disease</th>
<th>Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic conjunctivitis</td>
<td>39</td>
<td>91.9</td>
</tr>
<tr>
<td>Blepharitis</td>
<td>3</td>
<td>6.8</td>
</tr>
<tr>
<td>Disease of the lacrimal duct</td>
<td>4</td>
<td>9.2</td>
</tr>
<tr>
<td>Myopia</td>
<td>16</td>
<td>37.2</td>
</tr>
<tr>
<td>Hypermetropia</td>
<td>16</td>
<td>37.2</td>
</tr>
<tr>
<td>Astigmatism</td>
<td>2</td>
<td>4.4</td>
</tr>
<tr>
<td>Changes at the back of the eye</td>
<td>4</td>
<td>9.2</td>
</tr>
<tr>
<td>Weakness of sight</td>
<td>3</td>
<td>6.8</td>
</tr>
</tbody>
</table>

While the hypermetropia might be considered as due to the age of the workers, the other eye conditions should be attributed to occupational causes: eye strain and the effects of artificial light.

The pathology of these workers is analogous to that of workwomen engaged in the clothing industry, for though the work may be done in a workshop it is generally carried on at home in villages. The work is sedentary and carried out in a bad position (bent head) which favours congestion and strain in bringing about visual accommodation.

In passing through the villages where the women occupy themselves with lace-making, they are not infrequently to be seen working at the door of their houses; but in bad or cold weather they work in their rooms, often badly ventilated and lighted, which explains the high incidence of eye maladies among these women. When the work is done by artificial light this is often insufficient and inadequate. When they work “white”, they are exposed to the dazzling effect from the brightness of the work.

The defects of accommodation show themselves rather early and prepare the ground for more serious damage. Lace-making may be said to bring out latent morbid phenomena and to favour the development of anæmia, hysteria, and other neurotic symptoms in the production of which other factors such as heredity, environment, food, etc., play a part.

These workwomen easily and quickly acquire a lessened resistance to the effect of the work. When examining them the oculist does not find errors of refraction or of accommodation, or of muscular insufficiency, but he finds fairly frequently contraction of the visual field or the characteristic type of alteration of the visual field (hysterical copiopia). In old myopic lace-makers complications arising from the myopia are frequently observed such as central retino-choroiditis and exudation into the vitreous body.

For fuller details, see articles “Clothing or Garment Trade” and “Occupational Diseases: Eyes”.

Heller mentions that the nail of the left index finger must be well developed in lace-makers to enable them to draw the needle from the pillow during work. The nail of the right index finger, on the contrary, is kept short in order not to break the thread.

For hygiene, see article “Clothing or Garment Trade”.

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Lactic Acid


Lactic acid (formula, C₃H₅O₃) is now industrially prepared by starting with amylaceous substances and, in particular, potato starch. A glutinous substance is prepared which is transformed into a wort and treated with a diastatic solution. When the saccharification of the starch is completed carbonate of lime is added and the lactic ferment is scattered through it.

The lactate of lime produced is decomposed by means of sulphuric acid in order to liberate the lactic acid. It is prepared in a similar manner by starting with the mother liquors from crystallisation of lactose. It can finally be obtained also by inverting sugar by means of sulphuric acid and treating it thereafter with caustic acid.

Lactic acid is used as a reducing agent in the dyeing of wool (after mordanting with chrome), in the printing of cotton, in tanning, as a solvent for certain colours (indoline, nigrosine),...
in chemical laboratories, etc. Eczema
and ulcerations of the skin have been
reported among flax weavers (see arti-
cle "Flax and Linen Industry"), as
well as amongst dye workers, arising
from the acid in question which forms
a constituent of the baths used for
these products.

HYGIENE

The wooden vats used for sacchar-
ification of the starch should be placed
in airy and well-ventilated workshops.
They should be steam-heated. The
fermentation vats should be provided
with airtight covers and so placed that
the gases liberated are withdrawn
under the hearth of the generator or
into the chimney. The vapour and
evil-smelling gases produced by the
decomposition of the lactate of lime by
sulphuric acid should likewise be
directed to the chimney.

Crude lactic acid should be con-
centrated in closed apparatus at a
reduced pressure and purified, and
similarly also lactates destined for
pharmaceutical use should be put into
earthenware receptacles and not into
containers lined with lead. Residues
of sulphate of lime coming from the
manufacture of lactic acid should never
be allowed to accumulate in the
factory. All waste water should be
neutralised before it is allowed to leave
the factory.

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Laundries

French: Blancheries. — German:
Wäschereien. — Italian: Lavanderia. — Spanish: Lavadura.

In washhouses for the washing of linen
cloths of steam are liberated. Laundries
almost always have a washhouse attached,
since washing constitutes one of the most
important operations in laundry work.

Very often washhouses are found even
in public washing establishments.

Though to a great extent laundry work
is homework executed in private houses,
available statistics for large-scale under-
takings prove, however, the importance
of this industry. By reason of the greater
concentration in towns and the diminish-
ing aptitude and opportunity for home
laundry work, the industry is steadily in-
creasing. Usually ironing is also included
as part of the occupation, so that at the
present time laundry work affords occupa-
tion to as many women as any other
industry outside the textile trade.

There is an exceedingly wide range of
method followed in this industry, from
the primitive system of washing in open
tubs followed in domestic industry to the
highly organised systems with division of
labour followed in modern large-scale
laundries having the latest technical equip-
ment.

The unduly rapid changeover from one
extreme to the other has given rise to
undesirable anomaly between the two
systems. Smaller laundries are thus often
located in small unsuitable premises, often
really dwelling houses and never designed
for housing machinery, which shake with
the strain and which have small windows,
icapable of affording adequate ventila-
tion and light for the operations effected
with production of quantities of steam and
abnormal temperature.

Processes

Owing to the variety of methods
employed, an accurate description of
the work, typical of the industry in
general, is not possible, but in the
majority of large-scale undertakings
the following operations take place:

(1) Opening bundles or sacks of soiled
linen;

(2) Marking each piece;

(3) Separation of starched and flat
articles;

(4) Steeping;

(5) Washing with hot water, soap
and washing powder: this opera-
tion is followed or replaced by
soaping by hand;

(6) Rinsing;

(7) Wringing: done by hand by twisting
the linen or, more often, in
hydro-extractors which remove the
excess of water;

(8) Drying: the linen is placed in
tubs which are subsequently sent
to the drying chambers; in the
domestic industry it is often hung
in the open air on ropes or on
wooden frames.

The linen is then rolled in calender
machines in which folding is also
affected. It is thereafter starched and
finally ironed by hand or by machinery.

In some laundries the articles may
pass through seven or eight machines
for ironing alone. The drying chambers
are heated by steam or supplied with
hot air by propulsion fans. The
calender machines consist of huge
steam or gas-heated cylinders with
single or multiple rollers, and are
usually tended by young girls, who
stand in front of the rollers and feed
the edge of the material into the "bite"
of the roller or over the "lip" of the
single roller. A cloud of steam is given off as each fresh piece is inserted into the machine. The heat given off during this operation is sometimes very great. Over 90°F. may be registered on the feeding step of the machine, even in winter.

There is an endless variety of washing, wringing, starching, mangleing, and ironing machines—collar and cuff ironers, curling and gophering machines as well as electric or gas-heated irons. Factory work has caused a great increase in the employment of young unskilled labour (machine tenders), but at the same time conditions in factories, being subject to regulation, are, for the most part, greatly superior to those met with in domestic industry.

**Dangers — Pathology**

It is difficult to gauge accurately the effect of this industry on the health, since most of the diseases to which their occupation renders laundry workers liable are such as might equally well proceed from other causes. Certain investigations and statistical enquiries have shown health conditions in this industry to be in general satisfactory as compared with other industrial work. Yet, the heavy nature of the work and the attendant conditions, often of necessity highly unfavourable, undoubtedly provoke and aggravate certain forms of disease. The chief factors in introducing the various maladies from which workers in this industry suffer are: long and irregular hours (sometimes 72 to 76 hours, exclusive of mealtimes), constant standing and bad posture, atmosphere rendered hot and steamy by radiation from heat sources, lye fumes (often containing drops of lye in suspension), mechanical and strenuous effort, etc. These factors are usually present to a more pronounced extent in the case of the domestic industry, where the work is often executed in a room heavy with steam, which condenses on the walls and ceiling.

Where it is not possible to dry the linen outside (in smoky towns), the wet material flaps day and night across small inadequately ventilated rooms and passages, excluding light and air. The drying stoves and stoves or fires for ironing cause oppressive heat, rendered more obnoxious by the close odour of stores of soilied linen and fumes from the stoves, especially when the room is badly ventilated and without any provision for the removal of steam and bad air.

Miss May Smith (1922) conducted an enquiry into conditions in several London laundries where she found, for instance, in one case a temperature of 80°F. in November and in another, in summer, a temperature exceeding 90°F. The difference between laundries is enormous; for with a similar outside temperature of 61°F. the average temperature inside two laundries were 73°F. and 84°F. Very great differences were also met with as regards ventilation. Miss Smith is of opinion that were the problem seriously considered it would be possible to introduce universally such conditions of work as those at present obtaining in the best establishments.

As regards personal hygiene, one of the most important aspects of the question is the transfer of most of this work to immature young girls, who are specially liable to the bad effects of the occupation as exercised under the conditions above referred to.

Varicose veins are easily developed and ulceration and flat-foot are common evils resulting from constant standing. In addition to this the working of a foot-pedal, shaking and wringing linen, etc., are apt to exercise a bad effect on the genital organs. The rest obtained on "short days" by no means compensates for the overstrain and fatigue experienced on "long days". An English medical officer has drawn attention to the danger presented by the use of a product containing aniline oil for marking the linen. The report of the English Medical Inspector of Factories for 1924 contains a reference to two cases of skin absorption of aniline with vertigo, headache and cyanosis, affecting girls in a laundry using an ink solvent (containing aniline) to remove stains of indelible ink from a table-cloth, for a period of one hour.

Eczemas and skin eruptions are common, being due to the constant use of hot water and soap, both cutaneous irritants which remove protective fats and soften and diminish the skin and cause damage to the nails, which become loosened without, however, causing pain. They only rarely, as a matter of fact, fall off, so that certain authorities hold that it is not accurate to describe the effect as an "affection". Amongst workers occupied in the hot moist atmosphere of the laundries, there has been noted mycosis of the external canal of the ear due to *Aspergillus nigericus* or *flavescens*. 
which causes marked irritation, not only to the wall of the canal, but also of the membrana tympani, and consequent impairment of hearing. Affections of the upper respiratory passages are to be described to steam and to the alkaline fumes present, which dry the throat, give rise to thirst, and often lead to habits of intemperance. For this reason it was actually the custom in certain establishments to supply the workers with beer during a rest interval.

Investigation undertaken in France has proved the prevalence of pulmonary tuberculosis amongst workers in laundries, but great variance in statistics for different regions in regard to tuberculosis would appear to indicate that specially unfavourable conditions and not so much the work in itself, when carried out under the best hygienic methods, are responsible. One authority, while asserting that tuberculosis is very widespread in this industry, states that incipient forms of it are rarely diagnosed and treated as anaemia. The same author draws attention to the part played by heredity and infection, adding in this latter connection that many of the victims —are widows of consumptive husbands forced to take up the work in question in support of themselves and their families.

For these reasons it may be concluded that the work in itself is not conducive to the disease, but merely constitutes an unfavourable factor in its spread and development. Conditions peculiarly unfavourable to persons with a tendency to tuberculosis have been noted in departments where they are engaged all day in carrying heavy loads of wet clothes in a steamy atmosphere, often up to the ankles in water and soapsuds.

Bezançon (1923), of Boulogne-Billancourt, wished to investigate the accuracy of the current view of prevalent tuberculosis infection amongst laundry workers. The population centre in question (Boulogne-Billancourt), comprising 65,000 inhabitants, affords occupation to 5,000 laundry workers engaged in 400 establishments. While the tuberculosis mortality is high (26 to 30 per cent. of the general mortality) it affects chiefly amongst the laundry workers the men engaged in heavy work (steeping, machine-work, delivery, ironing) rather than the male and female workers engaged on the so-called dangerous operations (sorting, marking soiled linen, etc.).

Bezançon is of opinion that the cause of the tuberculosis incidence amongst adults in this industry is to be sought not in the occupation itself so much as in certain conditions liable to develop the disease amongst workers suffering from latent tuberculosis due to family infection at an early age. Direct infection in the industry when such exists would appear to be rare in the case of an adult. It is, however, very frequent amongst the children of these workers, especially children of small employers living in overcrowded workshops where they play with heaps of soiled linen which lie around in the common room.

Laundresses and ironers most usually present an anaemic appearance, characteristic of people who work in a restricted space and in hot moist air, inhaling coal gas which escapes from the tubes and jets (particularly carbon-monoxide). They complain of headache, fatigue, and exhaustion (Lehmann). The use of iron furnaces to heat the irons often gives rise to collective cases of poisoning by carbon-monoxide and even by arsenical compounds. In this connection may be recalled the poisoning of six women who suffered from the following symptoms: vomiting and loss of power in the legs — in one case almost complete paralysis with complete paraplegia below the knees and loss of patellar and plantar reflexes due to the presence of arsenic in the coal used for heating the stove. While no carbonmonoxide could be detected in the air samples taken, a noticeable portion of sulphur dioxide was found, which led the analyst the suspect also the presence of arsenic in the coke. He found 1/14 grm. per lb. (or 0.001 per cent.). Arsenic was also detected in the urine of two of the worst cases.

In an ironing room with gas irons, there was found 0.3 to 0.8 and even up to 1.4 c.c. of carbon-monoxide per 10 litres of air, and the carbonic acid content of the atmosphere reached 12.24 c.c. in 10 litres. The reduction of the haemoglobin by 10 per cent. was established as having occurred in the case of 25 per cent. of the workers.

Wilson, the English factory inspector, has demonstrated statistically the higher carbonmonoxide content in ironing shops using generator gas than in those using ordinary lighting gas. For this reason the use of generator gas has had to be abandoned in many establishments because of the occurrence of headaches, faintness, etc.

An enquiry was conducted by Miss May R. Mayers, medical inspector, New York State, in 1924 into hygienic conditions in New York laundries and the influence of such conditions on the health of workers. She also studied heart strain and strain of the vascular
system, and collected data regarding systolic and diastolic blood pressure, the pulse pressure, examination of the heart and urine, etc. This authority found as evidences of cardiac strain that the systolic pressure was abnormally high and the diastolic pressure abnormally low, that there was an accentuated aortic second sound, and a high pulse pressure, etc. The work was concluded by her to be unhealthy, especially from the point of view of heart strain and the circulatory system, in all but the very best laundries. The study in conclusion gives an account of the most adequate measures for improving conditions of work in the industry in question.

In certain establishments the ventilation system has been technically improved to the extent that once the blazing of the stove is over, the fumes are removed from the stove by means of ventilating fans, or drawn away by suction into a chimney.

Where one-foot lever machines are used for ironing, workers complain of fatigue and pains in the lower limbs, while a certain number of beginners have been known to develop acute appendicitis and hernia.

Margoniner cites, as the occupational disease of ironers, synovitis of the long extensor tendons of the right arm, beginning about the medial end of the metacarpal of the thumb and extending midway up the forearm, sometimes also affecting the shoulder joint. In the cases studied, he found paresthesia of the fingers affecting the region of the ulnary nerve attended by dullness of the finger tips, tingling and irritation and involving pronounced atrophy of the space between the bones of the thumb and first finger. These symptoms are to begin with worse during the night, but pass off on resumption of work. They are due to pressure of the finger tips on the iron and to the habit of rubbing on starch with the fingers.

Gastric affections common amongst ironers are gastric catarrh and gastric ulcer, caused, according to certain authorities, by pressure of the abdomen against the top of the flat iron. Other prevalent affections are enteroptosis (displacement through stooping position, constipation, etc.). Chronic muscular rheumatism and articular rheumatism are also fairly frequent, and occasionally cases of arthritis due most probably to a complex of causes, including bad nourishment, bad posture, etc. Other common affections are cardiacgia, kidney trouble plosis (due to the constant stooping position), retro or anteflexion of the uterus, dysmenorhea, hysteria, anaemia, etc. Two cases of death from tetanus were reported in a laundry affecting a man injured while starting up machinery, and a girl who got a splinter into her hand while washing up the mess-room floor, the flooring having probably been infected by the workers' boots. The question of the contraction of infection from soiled linen also presents itself in considering risks present in this industry. A Massachusetts investigation in this connection, however, proved negative, even as regards "markers", and general health conditions were found satisfactory.

Nevertheless, instances are known where infection has been transmitted, and Uffelmann cites cases of typhoid and cholera transmitted to washer-women by infected linen. The danger is probably greater in home and hospital laundries, where statistical data are lacking.

There is some risk of explosion in laundries where gasoline is used, and the bursting of hydro-extractors constitutes a certain risk. Burns are frequent among ironers, and a great variety of machine accidents which cannot, however, be described as typical owing to the great variety of kinds of machinery employed in the industry. Finger accidents are often sustained by workers attending to calender machines through the fingers becoming entangled in a hole or a string in the material and drawn between the rollers of the machines.

It has been stated that the hard nature of the work in general causes the women especially to be worn out while still quite young. They are also alleged to be rougher and more intemperate than women engaged in other classes of industrial work.

**Statistics**

The experience of the Leipzig Sickness Fund in regard to this class of workers shows the total number of days lost for all sickness to be under the normal figure for all workers, but the time lost on account of skin affections proved to be double the amount for all workers in general, while for rheumatism of the joints it was 40 per cent. higher than the average. The same experience shows a morbidity rate of 0.73 days per 100 workers and washers and a mortality hazard of 0.71 per cent.

In course of an enquiry effected in Belgium and covering 42 laundries employing 3,024 workers (2,309 of which were women), the tuberculosis rate was found to be only 9 per cent., amounting, however, to 16.2 per cent. amongst those directly engaged in the handling of soiled linen.
Of 45 male workers engaged in carrying heavy loads of wet clothes and often up to the ankles in water, 11 (24.4 per cent.) were tubercular or had suffered from pneumonia or bronchitis. In regard to throat and nose affections, the morbidity rate for laundry workers in general was found to be 44.5 per cent, and for those handling soiled linen 84 per cent. A quarter of the workers suffered from rheumatism. An examination for heart disease revealed five cases of dilatation and there were two cases of inguinal hernia. Of the workers 17.5 suffered from flat foot, 30.7 from varicos veins, and 20 per cent. from anaemia. Nineteen cases of miscarriage were found to have occurred in a total of 46 married women.

In the United States the mortality rate for tuberculosis was only 16.3 per 100 deaths from all causes (1909) for both sexes; in France, amongst 283 laundry workers (Landouzy) the percentage of death from tuberculosis was 25 for male workers and 56 for female workers. Of 12,000 workers in this industry one-third of the laundresses and female ironers and one-half of the male workers examined were found to be suffering from tuberculosis of the respiratory organs. The women appeared to be affected earlier (about 30 years of age) than the men, who were chiefly attacked at ages varying between 40 and 45.

According to the 1920 census, there were, in the United States, 396,756 laundresses. The mortality according to age groups and diseases was as follows in 1909:

<table>
<thead>
<tr>
<th>Age at death</th>
<th>Number of deaths from all causes</th>
<th>Typhoid</th>
<th>Pulmonary tuberculosis</th>
<th>Cancer</th>
<th>Apoplexy and paralysis</th>
<th>Heart disease</th>
<th>Pneumonia (all forms)</th>
<th>Bright's disease</th>
<th>Suicide</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years</td>
<td>212</td>
<td>2.9</td>
<td>3.0</td>
<td>3.0</td>
<td>1.1</td>
<td>1.5</td>
<td>4.0</td>
<td>1.7</td>
<td>1.9</td>
<td>3.0</td>
</tr>
<tr>
<td>35-44</td>
<td>216</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.3</td>
<td>1.3</td>
<td>3.0</td>
<td>1.5</td>
<td>1.9</td>
<td>2.8</td>
</tr>
<tr>
<td>45-54</td>
<td>216</td>
<td>5.5</td>
<td>11.5</td>
<td>11.5</td>
<td>12.5</td>
<td>12.5</td>
<td>13.5</td>
<td>13.5</td>
<td>13.5</td>
<td>3.0</td>
</tr>
<tr>
<td>55-64</td>
<td>165</td>
<td>5.4</td>
<td>7.4</td>
<td>10.4</td>
<td>12.7</td>
<td>13.5</td>
<td>13.5</td>
<td>13.5</td>
<td>13.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Among 165 female workers under observation (Brooklyn, N.Y.) during three years, there were 1,876 cases of sickness distributed as follows: 436 cases of gastric disease, 323 cases of dysmenorrhoea, 124 of colds, 55 of sore throats, 36 of neuralgia, and 31 of rheumatism. The number of accidents in laundries was relatively slight, for amongst 95 persons only two accidents were reported in five years, and in another instance among 54 persons there were about two accidents attributable to carelessness in fifteen years.

Hygiene

Laundries should have concrete floors with uniform impermeable surface sloping towards a drain. They should be well aired and thoroughly ventilated. Slatted wooden platforms inclining towards a drain should be provided for the workers to stand on. All flooring should be kept clean and in good repair. Rubber aprons and water-tight boots should be provided for wet work. Laundries should be well lit, by good artificial lighting with absence of glare, where daylight is not available. Natural ventilation, being as a rule inadequate should be supplemented by mechanical ventilation, with exhaust installation to assure effective air exchange, and, at the same time, removal of clouds of steam. Such a system is absolutely essential for places where drying and wringing by hydro-extractors is effected. Tubs should be provided with covers and surmounted by hoods to draw off the steam into a chimney or outside. This method is, however, in itself inadequate, since evacuation of the hot air by hoods in this manner allows of the entry of outer air at a lower temperature, and this gives rise to the continuous formation of fresh steam. It is, therefore, necessary to heat the air which is sent into the workroom or at least dry it previously by passing it through hygroscopic material and allowing it to enter at a low temperature.

According to Bargeron, the problem was very satisfactorily solved in one workroom in which the tubs were surmounted by metallic hoods connected with a ventilating shaft having access to the outside air. Piping for the supply of dry air was installed near each tub. Supplementary piping was connected with a curved nozzle, which took the form of a detached rim enclosing the hood and having at regular intervals apertures directed at the same time towards the inside of the hood and downwards over the tubs. By way of these apertures there was supplied continuously from an aero-condenser a current of hot air which swept the surface of the liquid, and in this way ensured dissolution of the steam as it formed. There was no fear of undue air pressure in the surrounding atmos-
provided communication with the outside atmosphere.

Dirty water should be withdrawn by a sewer into subterranean channels. Where no sewer is available, the water, before being allowed to flow into a stream or river, should be subjected to disinfection. Measures of protection against fire, escape of gas and liberation of toxic or disagreeable fumes and of smoke should be adopted.

A separate room should be set apart for sorting the linen, which should be previously disinfected, more especially when belonging to houses or institutions where there are patients suffering from contagious disease, in the event of such disinfection not having been effected on the spot. Clean linen should never be deposited in the sorting room, which should be particularly well ventilated in order to exclude bad odours. The linen should be brought in in closed receptacles which should only be opened on arrival in the laundry. All washed and unwashed linen should be kept strictly separate and handled apart. No food should be partaken of or cooked in rooms where clothes are handled, but a separate room should be provided for this purpose. Good sanitary washing and cloak room accommodation should be provided, and a good supply of drinking water should be available for the workers.

As regards technical installation, attempt should be made to replace as far as possible hand work by machine work, not only for actual washing, but also for ironing. The use of electric irons is now becoming more and more general in substitution for the former heavy types of iron heated on coal fires. This system not only prevents general disorders arising from inhalation of noxious fumes, but also the occurrence of cases of synovitis, paresthesia, etc. This system not only prevents general disorders arising from inhalation of noxious fumes, but also the occurrence of cases of synovitis, paresthesia, etc. This system not only prevents general disorders arising from inhalation of noxious fumes, but also the occurrence of cases of synovitis, paresthesia, etc. This system not only prevents general disorders arising from inhalation of noxious fumes, but also the occurrence of cases of synovitis, paresthesia, etc.

LEGISLATION

In France, the employment of young persons under 18 years of age in workshops where soiled linen without previous disinfection is handled is forbidden. In Holland, young persons under 18 years of age are excluded from unpacking, sorting, and marking soiled linen, and adolescents from machine work in ironing rooms.

In general, legislative provisions provide for the application of hygienic measures in laundries in the interests of public health. Special measures of hygiene have, however, been issued for the workers in this industry in Denmark (Order of 23 January 1908), France (Decree of 13 October 1913), Great Britain (Order of 23 April 1920), Netherlands (Act of 1920, section 5, subs. 56 et seq.), Yugoslavia (Regulations of 25 October 1921, sections 208-215).

The Dutch law provides minima for height and cubic space of the workrooms, more especially where heating is by means of stoves, etc. The French, British and Yugoslav regulations comprise detailed provisions for steam laundries.

Soiled linen may not be introduced into the workrooms loose, but only enclosed in bags, rolls or special covers or other approved receptacles.

Before handling, soiled linen should be disinfected (immersion in a boiling alkaline solution or sprinkling with disinfectant). Bags or cases having been used for transport should also be disinfected by the same method.

The introduction of soiled linen into rooms where clean linen is kept should be forbidden. All water used for steeping and washing should be directly withdrawn from the workrooms by enclosed piping.

The workers should be provided by the establishment with working clothes kept clean and in good repair. The bringing of food and drink into the workrooms should be forbidden. General regulations in regard to liquids and fumes, as well as to the protection of machinery, should also be enforced in this industry.

Many legislative systems (Italian. Dutch, etc.) have also passed regulations limiting the length of the working day in laundries.

Dutch law also requires compulsory notification of cases of peripheral paralysis occurring amongst laundresses.

BIBLIOGRAPHY


Lead


Lead (symbol, Pb) has an atomic weight of 207.2 and a melting point of 327° C.; it is very rarely found in a metallic state in nature, but, on the other hand, is very abundant in combined forms, especially with sulphur. Sulphide of lead or galena (PbS), which is generally argentiferous and contains in its pure state about 86 per cent, of lead, is the most important of the ores used for the extraction of lead. Ores of less practical importance are the following: cerusite (PbCO₃) or natural carbonate of lead; anglesite (PbSO₄) or sulphate of lead; pyromorphite (Pb₃(PO₄)₂ PbCl₂), orphosphate and chloride of lead; mimetesite (As₂O₅), Pb(PbCl) or arseniate and chloride of lead; phosphogenite (PbCO₃ PbCl₃); mendipite (PbO PbCl₂), etc.

The following, which are mixed with chalk and clay and oxide of iron, should be mentioned: matlockite (galena with a streak of cerusite and fluorine) zinckenite (PbSb₂S₄); the red ore of lead or crocoisite (PbCrO₄); wulfenite or yellow lead ore (molybdate of lead), etc. Nardoite or bulangerite are used particularly for the preparation of antimoniated lead.

These different minerals are not pure, but are generally mixed with one another or with other metallic compounds. Thus, for example, galena is often associated with carbonate of lead, compounds of antimony, either arsenical or sulphurous, or with silver or zinc.

In the various countries the production of lead ore (monthly average for 1930) in metric tons was as follows: United States, 45,884; Mexico, 20,936; Australia, 13,884; Spain and Tunis, 8,089; Canada, 12,084; Burma, 6,744; Germany, 9,674; Italy, 2,016; Poland, 1,383, etc.

Lead is not only extracted from the ores which have been mentioned above, but also from certain by-products from metal works and other industries, such, for example, as lead ashes from zinc smelting works; deposits (rich in lead sulphate) from lead chambers; dress from refining lead; residues from white lead factories, containing traces, sometimes considerable, of carbonate of lead; skimmings from lead refineries; fumes collected in flues from smelting furnaces.

Chemical Properties and Industrial Operations

Lead is a bluish-grey metal, with a bright metallic lustre when freshly cut, which becomes dull on exposure to damp air, due to the formation of lead oxide; it is so extremely soft that it can be easily dented with the finger nail, or cut with a knife. It can be reduced to very thin sheets and drawn out into very fine wire.

It melts at about 335° C. and boils at about 1,525° C. (between 1,500° and 1,600° C.), emitting noxious fumes. In a very finely divided state it is liable to spontaneous combustion, even at ordinary temperature.

Lead in a mass is not attacked by sulphuric or hydrochloric acids, which, on the other hand, attack finely divided lead. Nitric acid dissolves it in the form of nitrate; acetic and other organic acids attack it in the presence of air. Distilled water, from which the air has been removed, does not attack it; but aerated water dissolves it to a certain extent in the form of hydrate. Generally, the quantity dissolved by water depends on the degree of softness of the water; rain water comes first, containing hardly any salts and much oxygen, carbonic acid, and ammoniacal compounds.

Lead Mines

The ores are got by excavation in drifts which may reach a depth of 3,000 metres and more. The bearing almost always necessitates the use of explosives. The work is carried on in the same manner as in coal mines, and all regulations for hygiene and the prevention of accidents laid down for those mines should be applied to lead mines.

Very often a first sorting of the ore is made in the workings, even at the face; in other mines the ore is ready to go straight to the smelting works.

In the workings the attention of the hygienist must be given not only to ventilation, lighting, and humidity, but also to the various kinds of dust which exercise not only a mechanical action on the respiratory passages, but also a general toxic effect on the system — an action which has not always been sufficiently taken into consideration.

It is evident that the inhaled dust of galena is absorbed less rapidly and easily than that of cerusite, but the danger is not less great, although it causes symptoms less marked than those due, for example, to white lead. The danger is naturally less when the ore is moist, and it is greater if the miner takes his food at his place of work without adopting those measures of personal hygiene which are indispensable for all unhealthy occupations.

In order to improve the value of the ore as it comes from the mine by the removal of vein-stone, such as carbonate of lime, sulphide of baryta, or fluor-spar, as well as to diminish the expense of transport and facilitate
further treatment, lead ores are first of all subjected to mechanical preparation. This includes several operations: breaking, often by hand, into pieces of a uniform size; picking, also often done by hand, to get rid of pieces composed chiefly of vein-stone. Thus are obtained a rich ore and a poor one. The first can be calcined at once; the second is subjected as a preliminary to "stamping" and several washings to remove the earthy matter.

The ore so obtained which is called "schlich" (mud) is sometimes crushed in pestle or ball machines, then it is sorted according to the size of the pieces by the use of sieves, revolving cylinders, and perforated sheets of iron, or cylindrical sieves; after which it is classified according to its density, which is determined by levigation or capillarity. If the distance from the washhouse to the smelting works is short, the pieces arrive sufficiently moist not to give off any dust. If otherwise, and especially if ores from overseas are concerned, the product is dry and very dusty. This condition is more pronounced if the ores are delivered in very small pieces, or oxidised compounds of lead are involved, such as cerusite and anglesite.

Lead-Smelting Works

The ore so obtained is sent for treatment to the smelting works.

First and foremost the ores are analysed chemically to determine their content in lead and other products with a view to obtaining adequate results for metallurgical purposes. A sample of ore in pieces is crushed by the so-called wet process, ground, dried, and sent to the chemical laboratories. All operations, as well as the cleaning of apparatus, must be carried out with care so as to prevent the liberation of injurious dust.

Although the working conditions differ at the various smelting works, certain fundamental principles are nevertheless commonly observed.

The ores are mixed according to their different compositions in order that the melted material may have an average proportion of lead and a good composition from the point of view of metallurgical requirements.

Charging the furnaces is done with alternate layers of fuel and ore, which are put in at the furnace mouth. The mass is stirred with a shovel, but in some smelting works mechanical mixers are used.

Dry ore should be moistened by means of an independent dust-laying hose connected to a supply of water. This measure cannot, however, be used in the Huntington-Heberlein process before mixing. In this case it is not possible to avoid raising dust, especially if the moistened ore arrives too late. The ore is turned over with the spade and put in heaps. It is best to do this mixing in a closed conical drum, at the discharge opening of which is a watering rose for moistening the furnace charge. Sometimes adequate ventilating shafts are used, which are connected by means of aspiration and filtration to dust collectors.

Müller has pointed out the high proportion of lead in the air of smelting works at Pribram, even if moistened ores are used, when the crushing machines are not closed hermetically. As a matter of fact, in 28 litres of air taken in the workplaces, he found 0.4 to 0.5 mg. of lead calculated as oxide.

When the mixing and crushing of the ore is finished, the product is stored and kept in the wet state. But in the case of lead clinders, or other lead residues, they should be immediately fed into the smelting furnaces.

The different kinds of ore require special treatment. Thus, for example, for cerusite or rich ores, the reduction is simply effected by calcining with charcoal on an open hearth; the lead collects in the smelting sump. If, on the contrary, the ore is poor in metal and contains little sulphur or other metals, then the method by precipitation is employed. The ore is melted at a high temperature, by preference after calcination, with coke and scrap iron. Sulphide of iron and metallic lead are formed. This method has, however, been almost abandoned, for it requires much fuel and gives dross still too rich in lead.

As regards galena the nature of the vein-stone has also to be taken into consideration. Flux materials, such as lime, scrap-iron, or litharge, are also added to the ores with the object of obtaining a fairly liquid dross.

The extraction of lead from galena is carried out according to two principal methods: by roasting and reduction, or by roasting and reaction.

The reduction method, which is used chiefly for very impure ore with silica vein-stone, transforms the sulphide into oxide, which is reduced. The second method, which is used for pure rich ore, with little silica, is based on the decomposition of a portion of
the sulphide into oxide of lead and sulphate of lead.

When the reduction method is employed, it is carried out on Scotch hearths, which are rectangular, under a cowl with an exhaust shaft.

Air, heated by being passed through the double lining of the furnace, reaches the melted ore, and oxidises the sulphide of lead which it transforms into litharge, whilst the sulphur in burning passes into the state of sulphur anhydride. The charcoal then reduces into lead the bioxide of lead which has been formed.

The method by roasting and reduction is very important, for it is used particularly for ores rich in silica vein-stone.

Picked ore is mixed with "schlich", with granulated metal from castings, dross from previous smeltings, debris from the floor of cupelling furnaces, as well as with the first products of the oxidation of lead from cupelling furnaces. All these materials play an active part in the smelting. In the course of roasting, the silica displaces the sulphuric acid which is formed and gives a silicate of lead: the iron in its turn reacts and forms a sulphide of iron. The fire, being forced by a blast, decomposes the sulphates which are formed, and by the addition of lime, which facilitates the melting, the mixture of sulphates and oxide and silicate of lead is reduced.

The process of reduction is carried out in shaft furnaces, which have the shape of a double cone, of which the upper part is called the furnace and the lower the hearth. The floor holds a mixture of clay and charcoal tightly packed, which forms a hollow leading outside the furnace. The opening for tapping passes through the lower part of the hearth and gives exit to accumulated liquid products, which are collected on a second hearth quite outside the furnace.

Condensation of lead fumes and lead oxide, which are driven off by the blast, takes place above the upper cone or breast of the furnace, where are also placed the closed doors for charging the furnace and removing the condensed products.

When the material is tapped from the lower reservoir to the second on the outside, the metallic product obtained is composed of two layers, one of which, the lower, consists only of metallic lead, and the other, the upper, of sulphide of lead with other metallic sulphides present in the ore and of sulphides of iron. This layer, called the
lead matt, quickly solidifies and is removed by the workman, who can thus draw the metallic lead and run it into moulds. The matts are treated to extract the metallic lead. Copper, which may be found in the ore, combines during these reactions with sulphur and is a considerable component of the fourth matt, which can thus be considered as a cuprous ore. It is, as a matter of fact, called "copper matt".

The method of roasting and reaction is used in most large lead works which use ores with a vein-stone which contains but little silica.

The operations are carried out in a reverberatory furnace, known variously as the sloping hearth, the English, Carinthian, or Belgian furnace, where the crushed ore is heated to redness.

Under the action of air, the roasting changes a part of the sulphur into oxide and sulphate with a liberation of sulphurous anhydride.

Oxidation of the "schlich" is obtained by mixing the mass; the oxide and sulphate react on the sulphide with sulphurous anhydride and metallic lead as resultants; this reaction is obtained by closing at the right moment the openings and urging the fire with the blast.

The converter method is to-day largely adapted to the metallurgy of lead. The Huntington-Herberlein process with its various modifications allows the reduction of the sulphide by melting iron with 5 to 15 per cent. of caustic lime, according to the quantity of sulphur contained in the ore. A jet of air under pressure oxidises the lead, whilst the sulphur is removed either as sulphurous anhydride or as sulphate of lime. The anhydride is recovered for making sulphuric acid.

Several works carry out the extraction of lead from the ores or other products by washing with brine.

This process is based on the fact that the chloride and sulphate of lead are soluble in a saturated solution of sodium chloride. In a dilute solution of salt the solubility of lead salts is less than in pure water, but in concentrated solutions the solubility is greater. As silver is easily precipitated by a saline solution, in the case of argentiferous lead a little acid or ferric chloride is added to prevent this precipitation.

This washing is used for residues from treatment by electrolytic zinc; for dust from sulphate of lead, a product from lead and zinc smelting works; for sediment of sulphate of lead from lead chambers; for oxidised ores.
containing carbonate or sulphate of lead; for concentration tailings, containing sulphide of lead or silver; and for complex sulphur ores of zinc, lead, and iron.

In order to change the lead from its soluble form in one of these various solutions obtained by washing, it can be precipitated either electrolytically, using anodes of iron or graphite, or by chemical means by hydroxide of zinc or spongy iron.

In some American smelting works the electrolytic method is used; this consists of casting working lead into plates as anodes suspended in electrolytes which are formed by solutions of fluosilicates of lead and hydrofluosilicic acid. Lead deposits on the cathodes formed by the thin plates of lead in a very pure state. The residue contains silver, antimony, arsenic, and copper. The danger from this method is very small indeed; but the process has not as yet been brought into general use.

Desilvering of Lead

Lead obtained by one of the processes described above is known under the name of “working lead”; if it does not contain silver, it is handed over at once for trade purposes.

Working lead obtained from galena is refined in order to extract in particular the silver that it contains, and also the antimony and other substances. The operation takes place in a cauldron placed in a covered furnace at a temperature of 800-950° C. Heat, conveyed by projection and ventilation tangential to the surface, oxidises the foreign elements as well as a small quantity of lead. The lightest elements, i.e. dross of sulphur, antimony, and antimoniated lead, become oxidised in the form of a spongy crust and come to the surface. They are removed by...

Fig. 29. — Work at a zinc slag distillation furnace.
oxidised and then removed by skimming.

The lead crystals, which contain less silver than the working lead, are taken up by means of a perforated ladle by hand or mechanically and conveyed to a cauldron or kettle alongside, where the operation is repeated. Thus there is a kettle containing poor lead and another containing lead rich in silver.

Recycling of the silver then follows either by the Pattinson or the Parkes process, which is also known as zincing.

In the first, the Pattinson process, the mixture of argentiferous lead is deposited in hemispherical kettles arranged in rows of 12-16, placed under an arch of masonry with a hearth and ash tray. It is then subjected to slow cooling which separates it into two parts: poor lead, which crystallises, and an alloy rich in liquid silver. The silver is separated by a series of meltings and successive separations. The process which was formerly done by hand is now done mechanically.

The Parkes process, or zincing, which has replaced the preceding process, is based on the capacity of zinc for absorbing silver from working lead and for the alloy so formed to be distilled, just as water or mercury are distilled.

Covered cauldrons are placed in special furnaces so that they are heated from below and at the sides, and in these zinc is melted at a temperature of about 1150° C. A certain quantity of this metal is added to the lead bath, which is vigorously stirred by hand or, better still, mechanically. On cooling, a triple alloy of silver-lead-zinc is formed, which collects as a scum on the surface of the bath. It is then drawn off by skimming and, after melting again with the object of removing as much lead as possible, the alloy rich in silver is submitted to fractional distillation. The precious metal is now obtained mixed with a little lead; while the zinc is returned to the process. Finally, the argentiferous lead is submitted to cupellation.

The last operation takes place in a reverberatory furnace; it depends on the property of lead to become oxidised in the air, forming a fusible oxide (litharge) which is driven off as rapidly as it forms. The metal pot is enclosed in a furnace heated by projection, while a blast of air plays on the surface. This operation is carried out at 1,000-1,150° C. A fresh refining takes place in a small crucible.

The run litharge may, however, give off noxious fumes; hence the need of using an exhaust hood connected with a ventilator. Between the furnace and the flue is placed a condensation chamber where the lead in the state of vapour is condensed and dust is deposited. It is also as well to provide ventilation here and to place of deposit before emptying the flues. Dry condensation is generally used instead of moist for practical reasons, and the workman has to enter into the chamber to clean it once or twice a year. In these conditions it is necessary to employ a ventilating fan with suitable regulation of the delivery of air, while care must be taken that the man works in the direction of the draught.

Whilst the Pattinson mechanical process eliminates danger from poisonous vapours set free by lead heated to redness and from handling lead crystals, the new system is nevertheless preferred because it is less dangerous and because the mechanical mixing does not require the continued attendance of a workman. The temperature is easily regulated, overheating is avoided, and good general ventilation, combined with the use of exhaust hoods, prevents the liberation of poisonous vapours into the workshop.

Sources of Poisoning

The industries in which lead is run, rolled, and cast in making pipes, gratings, plates, pig-lead, and small moulded objects, the occupations of plumber, galvaniser, filemaker, and solderer, and cutting lead plates or burning of old lead paint are sources of frequent lead poisoning.

Another source of poisoning which should not be forgotten is represented by metallisation, a process very much used to-day in large works (see article "Metallisation").

The use of the oxyhydrogen flame upon paint exposes workers employed on the breaking up of old ships to the inhalation of zinc fumes. A definite attack may result which can easily be confused with influenza; it is characterised by a sweetish taste in the mouth and shivering, lasting usually for a day.

The inhalation of lead fumes by the same workmen is much more serious, for it causes a sensation of heaviness, constipation, colic, and sometimes symptoms of encephalopathy. It is calculated that workmen may inhale under these conditions 0.215 grm. of lead in the course of eight hours' work. The use of respirators diminishes, but does not remove, this danger.
In addition to risks common to all mining (see article "Mines (Hygiene in)") and to troubles due to physical environment regarding temperature and ventilation, work in the galleries exposes men to risk from the spontaneous combustion of pyrites, which liberates sulphurous anhydride and sulphuretted hydrogen.

The chief danger of work in lead mines and smelting works is that from lead poisoning, caused particularly by the inhalation and ingestion of dust loaded with lead. Clearly this danger will be greater or less according to the nature of the crude material, whether it be sulphides, sulphates, carbonates, or oxides of lead, its solubility, and its condition whether wet or dry. The operations of crushing, washing, and stamping are naturally more dangerous when done by hand than by machine, if the dust which is raised is not adequately controlled and carried away and if it is finely divided. During refining, exhaust hoods are not always applied above the melting pots; and then poisonous fumes may easily become diffused in the workplaces. Account must also be taken of spurtling particles of melted lead, which cause burns on the hands, arms and face. The running of lead is not very dangerous, as it is not too hot; and there are no fumes, or only very few. Work at reverberatory furnaces is dusty and arduous on account of the manual work and the heat; but fumes are only slightly given off. Furnaces of the Godfrey or Holthoff types are little used; with a certain amount of attention they only give off a small quantity of lead fumes; the Huntington-Herberlein type of furnace often gives off dust, fumes and vapours rich in lead vapours, fumes, and dust of lead, which threaten the workmen employed in the various processes, if these are not carried out in separate places. However, even the best organised works have not a department where risk of lead poisoning is not present to a greater or less extent. As a matter of fact, the workmen exposed to lead poisoning are very numerous; they include, for example, men employed in the removal of lead cinders, in roasting, crushing and smelting, in charging and discharging ores and their products, in removing dross, in dismantling and repairing furnaces, in cupellation, in distilling zinc ashes, in removing waste, in grinding and sifting litharge and packing it into barrels, and in attending to the suppression of dust.

As regards danger from lead dust, it
is sufficient to mention the great danger arising from beating sacks, and flue cleaning. Vapours as well as fumes, are liberated during smelting and pouring.

Hygienic conditions naturally vary from one works to another. This fact easily explains the fairly considerable variations in the frequency of lead poisoning. Thus, for example, in Germany in 1921, 30 cases of lead poisoning were reported from one smelting works, compared with 15 in all the other lead works. According to Muller, in a smelting works at Scheriau (in 1903) 330 kg. of lead were lost each day into the air through the flues and 30 workmen out of 153 suffered from lead colic. In the Friedrich smelting works, from 1887 to 1892, the sickness from lead poisoning decreased from 82.9 per cent. of workmen to 19.4. Other facts could be easily brought to show that improvements in the plant may be of very considerable advantage from viewpoints of both economy and health. As a matter of fact, Muller found repeatedly quite high proportions of lead in the air of workplaces: for example, in 5 cubic metres of smoke from a furnace he found from 8.5 to 22.7 per cent.; in another case strengths from 12.3 to 18.8 per cent. In 1 cubic metre of air he found 1.184 grm. of lead. On the basis of several analyses of the air of an English smelting works, Cowan estimated in 1910 that 0.5 grm. of lead would be inhaled by a workman on the charging platform of smelting furnaces.

Among other metallic lead industries, those which cause the greatest number of cases of lead poisoning are soldering work and preparing lead plates, as well as the work of breaking up ships. These cases are also generally very serious, for they are due to the inhalation of lead vapour in heavy doses.

Hands, tools, food, drink, and tobacco are liable to be soiled by lead dust; thus the entrance into the body of poison by the digestive organs is facilitated. Inhalation of lead dust and of particles of lead may occur, especially when other factors come into play, such as: carelessness on the part of the workman; youth, or poor physique; alcoholism; unhealthy conditions of work; and also a certain predisposition (see article "Lead Poisoning").

Among other dangers to which workmen at smelting works are exposed, the following should be mentioned: carbon monoxide, cyanogen and its compounds, arsenic, oxide, mercury (Biondi), tellurium, sulphurous anhydride, especially during roasting; fumes and dust from fuel and limestone; radiation from ore and metal during smelting.

Finally, exhaustion caused by lifting and handling heavy tools must not be overlooked; great sweating in consequence of high temperature; diseases arising from cold due to draughts and sudden changes of temperature, accompanied very often by digestive troubles caused by abuse of drink and especially of cold water.

Among the gases and fumes which are given off from smelting works and which damage vegetation and sometimes the health of cattle in the vicinity, sulphurous anhydride and lead dust should be mentioned as the most harmful, causing poisoning of domestic animals in the neighbourhood.

As has been said elsewhere, lead poisoning is quite frequently registered under the name of its symptoms, without taking into account their etiology. Thus the diagnosis may refer to diseases of the intestines, kidneys, heart, and articulations, or to gout and paralysis, without any information as to whether these morbid conditions are essentially or in part due to the toxic action of lead. The German Sickness Insurance Offices, for instance, do not as a general rule receive any record from the clinic where the patient is treated, nor is any modification eventually placed on the case sheets, with the result that numerous cases, especially the less serious ones, escape the knowledge of the inspectorate. As a matter of fact, according to section 343 of the Factory Act (R. G. O.), the Sickness Insurance Office should inform the inspectorate of every case of lead poisoning — just as of cases of poisoning by phosphorus, arsenic and mercury; further, the Offices, by virtue of the Order of 21 June 1922 (Prussian Ministry of Commerce) are obliged to send the same notification to the medical factory inspectors. Then chronic invalid workmen are deleted from the statistics.

However that may be, it is quite clearly established that lead poisoning, and especially its serious forms, such as encephalopathy, have no doubt diminished in German smelting works compared with the period before hygienic measures were taken; and this is due to the elimination of the most serious hazards. This improvement in the hygienic situation of men employed at lead smelting followed almost immediately upon the application of preventive measures; it has been observed for a long time in the smelting works at Brunswick, and in those of the Government at Freiberg.
The frequency of sickness, apart from good conditions of general management, depends in a definite way on labour turnover. As a matter of fact, it is often necessary to discharge workmen who are not familiar with the occupational risks, or who are not sufficiently clean in their habits. Besides, the frequency of sickness is also affected by increased risk due to sudden disturbances in the processes and to repairs. On the other hand, resistance to poisoning can be increased by good conditions of pay, food, living, and housing, and to sum up, by raising the standard of well-being, and by a healthy life lived under healthy conditions.

**STATISTICS**

Before examining the hygienic and sanitary conditions of workmen employed in lead and smelting works, it is advisable to know the results of certain enquiries made in these industries.

### LEAD MINES

Among the most important mention must be made of the enquiry made in Australia at the Broken Hill mines, which employ 6,538 persons exposed continually to the action of lead: 3,305, or 50.5 per cent., had worked for a period of ten years or less; 1,851, or 28.3 per cent., for more than ten and less than twenty years; 1,104, or 16.9 per cent., for more than twenty and less than thirty years; 1,104, or 16.9 per cent., for more than thirty years. (The report on the enquiry at Broken Hill has been criticized by Dr. C. Badham, Medical Officer of Industrial Hygiene, New South Wales.)

Out of 3,502 persons of the first group, 29, or 0.6 per cent., showed symptoms of lead poisoning. Of 1,851 of the second group, 23, or 1.2 per cent., had lead poisoning, as well as 30, or 2.7 per cent., of the 1,104 of the third group; whilst out of 660 workmen of the last group, 6, or 2.3 per cent., showed symptoms of plumbism.

Out of 61 workmen known to have lead poisoning, 27 had been employed solely underground. Of 660 miners who had been employed entirely underground for ten years and over, 1, or 0.15 per cent., suffered from lead poisoning. Of 412 miners who had worked entirely underground for more than ten and less than twenty years, 11, or 2.6 per cent., were affected. Of 271 miners who had worked entirely underground for more than twenty and less than thirty years, 10, or 3.7 per cent., had had poisoning. Of 67 miners who had worked entirely underground for more than thirty years, 3, or 4.5 per cent., suffered from lead poisoning. Of 196 truck-pushers and 63 vein-stone workers who had been employed entirely underground, 1 truck pusher and 1 vein-stone worker who had been alone were found to have lead poisoning.

### TABLE

<table>
<thead>
<tr>
<th>Number of workmen examined</th>
<th>Percentages affected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Below 40 years</td>
</tr>
<tr>
<td>Stonecutters Broken Hill underground workers</td>
<td>716</td>
</tr>
<tr>
<td>Broken Hill surface workers</td>
<td>1,440</td>
</tr>
<tr>
<td>Total</td>
<td>1,507</td>
</tr>
</tbody>
</table>

In Australia the workmen employed in sulphide of lead and zinc mines quite frequently have lobar pneumonia, which is particularly serious and ends fatally. As regards silicosis, the above-mentioned Commission of Enquiry at Broken Hill (1920-1921) also turned its attention to the incidence of this disease and examined 6,538 persons. The results are given in the following table:

<table>
<thead>
<tr>
<th>Number of workmen examined</th>
<th>Percentages affected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Below 40 years</td>
</tr>
<tr>
<td>Stonecutters Broken Hill underground workers</td>
<td>716</td>
</tr>
<tr>
<td>Broken Hill surface workers</td>
<td>1,307</td>
</tr>
<tr>
<td>Total</td>
<td>1,504</td>
</tr>
</tbody>
</table>

Of 726 persons who had worked both on the surface and underground for a period of ten years or less, not one was found to be affected by lead poisoning. On the other hand, as soon as the period of work exceeded this figure of ten years, an increasing percentage was noticed in relation to the number of years spent at work either in the mine or about it.

If the figures for arteriosclerosis and nephritis reported among the miners of Broken Hill are compared, for example, with those for stonecutters at Sydney, the following comparison is obtained:

*Figures for broken Hill are compared, for example, with those for stonecutters at Sydney, the following comparison is obtained:*
MINERS AFFECTED BY SILICOSIS

<table>
<thead>
<tr>
<th>Length of employment</th>
<th>Broken Hill only</th>
<th>Broken Hill and other mining centres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of persons</td>
<td>Percentages</td>
</tr>
<tr>
<td></td>
<td>Examined</td>
<td>Sick</td>
</tr>
<tr>
<td>Up to 10 years</td>
<td>461</td>
<td>6</td>
</tr>
<tr>
<td>From 10 to 20 years</td>
<td>590</td>
<td>29</td>
</tr>
<tr>
<td>From 20 to 30 years</td>
<td>140</td>
<td>24</td>
</tr>
<tr>
<td>Above</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>First series Number of persons examined: 4,397</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 10 years</td>
<td>689</td>
<td>7</td>
</tr>
<tr>
<td>From 10 to 20 years</td>
<td>582</td>
<td>32</td>
</tr>
<tr>
<td>From 20 to 30 years</td>
<td>283</td>
<td>44</td>
</tr>
<tr>
<td>Above</td>
<td>39</td>
<td>5</td>
</tr>
<tr>
<td>Second series Number of persons examined: 6,538</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rambousek in 1906 originally asserted that there was not a case of lead poisoning among 10,000 lead miners (galena) of Bavaria; but later he admitted that he had been able to detect some slight cases of lead poisoning among these workmen.

In a galena mine in Bulgaria Zweitkoff (1931) examined 75 out of 156 workers, 15 of whom were women, and found 27 cases of lead poisoning characterised by subjective and objective symptoms. He attributes this high incidence of lead poisoning to the dust raised during the hewing of galena, to the drinking water which was exposed to dust, to lack of personal cleanliness, to the operation of sorting the ore and perhaps also to transformation of the galenite into other more soluble compounds under certain conditions.

Some cases of lead poisoning have been reported among the miners of the department of Aveyron (France) and several cases among the miners of Sardinia (galena mines).

In English galena mines, cases of lead poisoning are rare, although cases have been reported among those who handle cerussite imported from Australia. Pneumonoconiosis and phthisis are more common. The mortality from tuberculosis among lead miners is calculated at 3.9 per 1,000 living compared with 1 for coal miners. Sometimes it would appear to be due to bad housing conditions (Oliver).

In England and Wales the comparative mortality 1 for the two periods 1900-1902 and 1910-1912 relating to “lead miners” is as follows 2:

1 “Comparative mortality” is the number of deaths, between the ages of twenty-five and sixty-five, which would have occurred when the rate of the occupational mortality for different causes and at different age periods is calculated on the number of the general male population, which at the time of the census of 1901 showed 1,000 deaths. This “standard” number of population was 71,005 men.

2 The statistics for 1912 do not provide figures for the category of workers termed “lead miners.”
COMPARATIVE MORTALITY OF LEAD MINERS, 1900-1902 AND 1910-1912

<table>
<thead>
<tr>
<th>Causes of death</th>
<th>Pulmonary tuberculosis</th>
<th>Respiratory diseases</th>
<th>Accidents</th>
<th>All causes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1900-02</td>
<td>1910-12</td>
<td>1900-02</td>
<td>1910-12</td>
</tr>
<tr>
<td>Lead miners</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All males</td>
<td>394</td>
<td>335</td>
<td>274</td>
<td>189</td>
</tr>
<tr>
<td></td>
<td>186</td>
<td>142</td>
<td>174</td>
<td>119</td>
</tr>
</tbody>
</table>

DEATH RATE OF LEAD AND TIN MINERS FROM PULMONARY TUBERCULOSIS

<table>
<thead>
<tr>
<th>Age group</th>
<th>15 years</th>
<th>20 years</th>
<th>25 years</th>
<th>35 years</th>
<th>45 years</th>
<th>55 years</th>
<th>65 years and over</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1890-1892</td>
<td>1.10</td>
<td>2.31</td>
<td>3.78</td>
<td>6.15</td>
<td>10.50</td>
<td>13.85</td>
<td>13.89</td>
</tr>
<tr>
<td>1900-1902</td>
<td>0.56</td>
<td>1.54</td>
<td>3.01</td>
<td>7.85</td>
<td>10.50</td>
<td>12.92</td>
<td>10.00</td>
</tr>
<tr>
<td>1910-1912</td>
<td>0.30</td>
<td>2.31</td>
<td>3.24</td>
<td>9.23</td>
<td>10.44</td>
<td>13.72</td>
<td>8.24</td>
</tr>
</tbody>
</table>

CAUSES OF DEATH OF LEAD MINERS: COMPARATIVE MORTALITIES

| Causes of death | Pulmonary tuberculosis | Pneumonia | Bronchitis | Other respiratory diseases | Circulatory diseases | Chro- 
|-----------------|------------------------|-----------|------------|----------------------------|---------------------|nco-
|                 |                       |           |            |                            |                      |phritis of the liver |
|                 |                       |           |            |                            |                      |                  |
| 1900-1902       | 1,514                 | 440       | 147        | 148                        | 85                   | 165                | 38               |
|                 | 1,206                 | 324       | 84         | 53                         | 137                  | 102                | 19               |
|                 | 1,165                 | 355       | 49         | 50                         | 60                   | 187                | 34               |

DEATHS AMONG LEAD MINERS IN WALES FOR THE PERIOD 1908-1918

<table>
<thead>
<tr>
<th>Age group</th>
<th>Causes of death</th>
<th>Number of deaths</th>
<th>Expected</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-35</td>
<td>Phtisis</td>
<td>2.3</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other respiratory diseases</td>
<td>0.6</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other causes</td>
<td>5.1</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All causes</td>
<td>8.0</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>35-45</td>
<td>Phtisis</td>
<td>3.2</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other respiratory diseases</td>
<td>0.8</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other causes</td>
<td>3.5</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All causes</td>
<td>7.5</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>45-55</td>
<td>Phtisis</td>
<td>8.2</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other respiratory diseases</td>
<td>4.1</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other causes</td>
<td>9.2</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All causes</td>
<td>21.5</td>
<td>21.5</td>
<td></td>
</tr>
<tr>
<td>55-65</td>
<td>Phtisis</td>
<td>8.4</td>
<td>28.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other respiratory diseases</td>
<td>7.7</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other causes</td>
<td>26.4</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All causes</td>
<td>36.5</td>
<td>36.5</td>
<td></td>
</tr>
<tr>
<td>65 and over</td>
<td>Phtisis</td>
<td>0.7</td>
<td>14.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other respiratory diseases</td>
<td>0.7</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other causes</td>
<td>25.6</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All causes</td>
<td>36.0</td>
<td>36.0</td>
<td></td>
</tr>
</tbody>
</table>

Comparison of the number of observed deaths from phthisis with those expected, particularly from the age of forty-five onwards, among lead miners in Wales, brings out the excess of mortality experienced due to dust inhalation.

In Italy, miners in Sardinia, according to an investigation of Loriga, become unfit for work at an earlier age than that of other Italian districts. This fact is strictly in accordance either with damage caused by mining or with greater precautions taken by employers to get rid of the less capable workmen.

The Sardinian miners marry less frequently and remain widowers more frequently than the miners of other districts. The miners' wives, like their husbands, have a higher percentage of early deaths. They also have a smaller number of children than other miners. Without entering into details of an economical kind, which would clear up several of the points under consideration, it is sufficient here to mention that if the hygienic conditions are in general bad, the conditions of safety are, on the contrary, better. So serious are conditions of living of these miners, that their average age at death is about forty-four years (Fronzia) compared with fifty-five for the peasant and agricultural group.

The sickness rate is also higher than for other regions; it increases — and this is important — with age. The commonest diseases are: lead poisoning, mercurialism, malaria, and respiratory diseases, of which pneumonia and bronchitis are the chief. According to Fronzia, the children of the
miners are difficult to rear; their height and weight are less than the average, and the same applies to chest measurement. These facts account for the great number of rejections at examinations for military service.

Lead-Smelting Works

The health conditions of German lead smelters are not exactly known, particularly in reference to lead poisoning. However, the reports of the factory inspection department supply facts regarding certain German smelting works.

In 1906 Rambousek found 150 cases of lead poisoning among 4,000 smelters. In four smelting works the average was from 10 to 11 cases of lead poisoning per 100 workmen.

An enquiry made by H. Engel in 1920-1922, and published in 1925, dealt with twenty workplaces employing 853 men. These workplaces were personally visited by the author with the object of detecting symptoms of lead poisoning, with the following results:

<table>
<thead>
<tr>
<th></th>
<th>Number of workmen examined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of workmen examined</td>
</tr>
<tr>
<td>Factories for lead pipes and sheets</td>
<td>9</td>
</tr>
<tr>
<td>Factories for metal stoppers (capsules)</td>
<td>2</td>
</tr>
<tr>
<td>Lead smelting works</td>
<td>3</td>
</tr>
<tr>
<td>Tinplate works and sheet metal works</td>
<td>1</td>
</tr>
<tr>
<td>Lead soldering works</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

Without entering into details of this very interesting inquiry it is sufficient to tabulate the observations on health made during the examinations:

<table>
<thead>
<tr>
<th></th>
<th>Number of workmen examined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of workmen examined</td>
</tr>
<tr>
<td>388</td>
<td>60</td>
</tr>
<tr>
<td>Subjective troubles:</td>
<td></td>
</tr>
<tr>
<td>Of the stomach</td>
<td>72</td>
</tr>
<tr>
<td>Various</td>
<td>83</td>
</tr>
<tr>
<td>Leaden colour</td>
<td>91</td>
</tr>
<tr>
<td>Blue line present</td>
<td>141</td>
</tr>
<tr>
<td>&quot; very marked</td>
<td>30</td>
</tr>
<tr>
<td>Increased blood pressure</td>
<td>59</td>
</tr>
<tr>
<td>Without subjective symptoms</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>—</td>
</tr>
</tbody>
</table>

At a further examination, 111 solderers and 20 tinners had their blood and urine examined. Engel found that 68 workmen among the 111 solderers had symptoms of lead poisoning; 19 had a haemoglobin value above 71 per cent.; 63 had polychromatic red cells; 85 had basophilic red cells, of whom 20 had the condition very marked; 120 had haematoporphyrin in the urine, of whom 28 exhibited it in a pronounced degree. Out of 20 tinners 21 had symptoms of lead poisoning, 2 had polychromatic red cells, and 2 had basophilic red cells.

An enquiry conducted by Schwarz in 1925 among workmen definitely exposed to lead poisoning, based on the results of blood examinations, enabled him to conclude that positive cases are in proportion to the extent that workmen are exposed to the inhalation of lead in the form of vapour or dust.

Smelters of lead with 44 positive cases out of 58 examined, men using high temperature flames in breaking up ships with 13 cases out of 14, ore-crushers in lead-smelting works with 8 cases out of 13, and smelters of the dross are all much affected. The search for haematoporphyrin in the urine has very often a positive result, which nevertheless does not run parallel with basophilic granulation, but is a useful diagnostic feature. On the other hand, examination of the blood pressure is of no advantage. The blue line and lead colic which are noticed among these workmen in the first months or even weeks of employment, are too well known to dwell upon here.

In Bavaria during the period 1927-1929, 85 out of 617 cases of lead poisoning notified affected founders and welders.

The smelting works of the Prussian Government at Hildesheim give the following figures:

<table>
<thead>
<tr>
<th></th>
<th>Workmen</th>
<th>Cases</th>
<th>Per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1913-1915-1917-1918</td>
<td>631</td>
<td>94</td>
<td>5.90</td>
</tr>
<tr>
<td>1919</td>
<td>138</td>
<td>1</td>
<td>0.70</td>
</tr>
<tr>
<td>1920</td>
<td>194</td>
<td>6</td>
<td>3.00</td>
</tr>
<tr>
<td>1919-1915-1917-1918</td>
<td>262</td>
<td>5</td>
<td>—</td>
</tr>
<tr>
<td>1919</td>
<td>81</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1920</td>
<td>72</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

In Prussia (1929) out of: 1,124 cases of lead poisoning reported, 304 affected lead founders.

If any proof is necessary of the advantages of good hygiene, it is sufficient to mention that the age of retirement for workmen exposed to lead now often exceeds fifty years. Thus, out of 887 smelters at the works of Friedrich and Walther Kroneck, there were, in 1906, 45 workmen
aged from fifty to fifty-five years, whilst in 1912 there were 88. In these smelting works 13 per cent. of the personnel were affected with lead poisoning in 1901; in 1912 the percentage was only 4. A commission appointed in 1925 to enquire into the health of the lead-smelting works of Port Pirie in South Australia issued a report full of interesting facts on the industry in question.

An enquiry made in 1910 had emphasised that complete figures did not exist to enable any approximation to be arrived at relative to the incidence of lead poisoning among the lead smelters. During the period 1907-1909 there were reported about 150 to 200 cases among smelters, pointers, and other workers in contact with lead. Lead poisoning being caused chiefly by poisonous fumes coming from the furnaces, the plant was promptly improved, which led to a rapid diminution in cases of lead poisoning. The investigators agreed that the general state of health of the manual workers was good. The return for the incidence of lead poisoning was more difficult, for there was no compulsory notification, and legal compensation only came into force in 1912.

The cases of which there is information were distributed as follows: for 1910, 1 case; 1916, 5; 1919, 5; 1920, 4; 1921, 3; 1922, 56; 1923, 89; 1924, 334; in the first five months of 1925, 126 cases. Cases of lead poisoning treated in hospital at Port Pirie were as follows: 1910, 10 cases; 1911, 9; 1912, 21; 1913, 58; 1914, 30; 1915, 22; 1916, 48; 1917, 31; 1918, 13; no case in 1919 or 1921, as the factory was not at work; 1922, 16 cases; 1923, 19; 1924, 46; the first five months of 1925, 12 cases.

It is probable that these cases only represent a portion of the lead poisoning occurring among manual labourers, most of the patients preferring to be treated at home. Attention should, however, be drawn to the fact that a medical referee board would have accepted as true lead poisoning only a small percentage of these cases; the others being probably due to chronic intoxication.

Analysis of the blood of 300 workmen did not show any objective modification of the leucocytes, polychromatophiles, poikilocytes, etc.; 89 basophilic granulations, which were slight in 53, moderate in 24, and strong in 12.

The 397 cases which were known to have occurred from 28 June 1917 to 31 December 1924 are classified as follows according to the special process on which the patient was employed:

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Smelting of metals</td>
<td>40 (4)</td>
<td>34 (2)</td>
<td>45 (3)</td>
<td>26 (1)</td>
<td>21 (1)</td>
<td>36 (2)</td>
<td>20</td>
<td>37 (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plumbing and soldering</td>
<td>31 (2)</td>
<td>19 (1)</td>
<td>3 (1)</td>
<td>7 (3)</td>
<td>11 (1)</td>
<td>11 (1)</td>
<td>8 (1)</td>
<td>6 (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Breaking up ships</td>
<td>—</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>32</td>
<td>32</td>
<td>18</td>
<td>24</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Other operations entailing contact with melted lead</td>
<td>—</td>
<td>13 (2)</td>
<td>16 (4)</td>
<td>17</td>
<td>9 (1)</td>
<td>12 (2)</td>
<td>19 (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacture of accumulators</td>
<td>35 (3)</td>
<td>40 (1)</td>
<td>47 (2)</td>
<td>52</td>
<td>58</td>
<td>35 (1)</td>
<td>23 (2)</td>
<td>36 (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Printing</td>
<td>29 (2)</td>
<td>16 (2)</td>
<td>9</td>
<td>8</td>
<td>10</td>
<td>3</td>
<td>8 (1)</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The tapping of metals</td>
<td>26 (1)</td>
<td>6 (1)</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1 (1)</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total of all cases of lead poisoning</td>
<td>546 (56)</td>
<td>779 (40)</td>
<td>289 (44)</td>
<td>332 (40)</td>
<td>347 (36)</td>
<td>326 (43)</td>
<td>244 (31)</td>
<td>265 (39)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

(The figures in brackets refer to fatal cases.)
In 1919 the reports of inspectors showed that a hall, used as a canteen, opened directly into the foundry of the factory, with the result that the dust contained 15 per cent. of lead.

In 1920 the increase in cases of lead poisoning is explained by the fact that one smelting works had a particularly high incidence with 23 cases.

The cases of lead poisoning notified in France among lead smelters and workmen brought in contact with metallic lead are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>1933</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smelting and lead working</td>
<td>124</td>
<td>144</td>
<td>149</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Printing works</td>
<td>39</td>
<td>33</td>
<td>34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacture of accumulators</td>
<td>250</td>
<td>323</td>
<td>392</td>
<td>312</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work with metallic lead</td>
<td>34</td>
<td>50</td>
<td>39</td>
<td>87</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Total of all cases of lead poisoning</td>
<td>1,065</td>
<td>1,919</td>
<td>1,343</td>
<td>1,505</td>
<td>1,040</td>
<td>1,595</td>
</tr>
</tbody>
</table>

In the State of New York the cases of lead poisoning have been as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>1919-1920</th>
<th>1921-1922</th>
<th>1923</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accumulator factories</td>
<td>140 (3)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Lead smelting works</td>
<td>19 (4)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Printing works</td>
<td>19 (4)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Lead works</td>
<td>11 (2)</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

In the State of Illinois:

<table>
<thead>
<tr>
<th>Year</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accumulator factories</td>
<td>11</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Lead smelting works</td>
<td>44</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Total of all cases of lead poisoning</td>
<td>101</td>
<td>83</td>
<td>134</td>
</tr>
</tbody>
</table>

In the State of Ohio from 1920 to 1925, out of 443 cases of lead poisoning granted compensation, metal-work accounted for 12 cases, enamelling for 14, and smelting works for 4. Most of the cases arose at accumulator factories, 145 cases; in painting automobiles, 114 cases; at white lead works, 54 cases; tetraethyl lead, 24 cases; and at painting work, 20 cases.

In Russia, Salosnow in 1926 examined 234 workmen of five sections of the lead works, and found 15 per cent. of these men were aged from twenty to forty years; 13.2 were over fifty years; 33.5 per cent. had worked in the smelting works for less than three years; 44.4 per cent. from three to five years; 12.4 per cent. for more than fifteen years. Whereas 66 men (29 per cent.) did not show any important sign of ill-effects, the others, on the contrary, showed symptoms of disease; stated more precisely, 57 (24.3 per cent.) exhibited symptoms of infectious diseases; 51 (21.7 per cent.) of respiratory diseases; 7 (2.9 per cent.) of nutritional troubles. Only two had definite signs of pulmonary tuberculosis, whilst 43 (18.4 per cent.) could be considered as tuberculosis suspects. Lead poisoning was found in 26 workmen, 15 of whom (or 11.2 per cent.) were employed in the metallurgical section.

**DETECTION**

For the detection of traces of lead in the air of workshops, the well-known methods can be used which are described in the article "Lead Poisoning" for the detection of lead in the body.

A known volume (from 5 to 10 litres) of air is aspirated from the atmosphere to be analysed by means of ordinary apparatus under precautions observed by experts in the subject.

The aspiration effectively mixes the lead vapour with, and fixes it in, a solvent, and arrests lead dust by filtration on wool.

The usual methods employed for detecting traces of lead are: transformation of lead or a lead compound into nitrate; treatment with sulphuric acid or soluble sulphates; a white precipitate forms, soluble in potash, and in boiling hydrochloric acid. This acid, as well as soluble chlorides, gives a white precipitate of lead chloride, which is insoluble in ammonia. Potassium chromate gives a yellow precipitate, soluble in potash; iodide of potassium gives a yellow precipitate, soluble on warming, which reprecipitates on cooling into yellow golden flakes. Sulphurified hydrogen with lead salts causes a black precipitate of sulphide of lead.

In 1903 Trillat suggested a new method for testing for lead based on the blue coloration, stable to heat, which the base of tetramethyl of diphenylmethane gives in a solution of acetic acid in the presence of some dioxides, such as that of lead.

The air sample is drawn through a filter of cotton wool which retains all the dust; it is then passed into an absorption tube containing dilute sulphuric acid to fix the lead vapours. The cotton wads are reduced to ashes by calcination after the addition of some drops of dilute sulphuric acid; the solution from the absorbing apparatus is evaporated to dryness and slightly calcined.

It is on these residues from calcination that the tests with the Trillat reagent are carried out. This reagent is prepared as follows: A mixture composed of 30 grm. of pure dimethylaniline, 10 grm. of formaldehyde, and 200 cc. of water acidulated with 10 grm. of sulphuric acid is heated for an hour in a water-bath. After cooling, it is rendered alkaline with a large excess of soda, and the excess of dimethylaniline is removed by passing into the solution a strong current of steam for ten minutes, until the last traces of amine...
are entirely removed. The cooled solution deposits a crystalline mass, which may be recrystallised once in alcohol to purity it completely. This process gives easily 15 to 20 grm. of the base. The reagent is prepared by dissolving 5 grm. of the base in 100 cc. of pure acetic acid. It is preserved in a closed bottle and shaded from light.

The solution should not be of a blue colour, nor give this colour on boiling. The reaction should occur in a medium acidulated by acetic acid, to the exclusion of mineral acids, even in traces. It is also necessary to present the lead in the form of a salt capable of regenerating the dioxide; this is done by oxidising it by an alkaline hypochlorite.

The substance to be analysed is treated by sulphuric acid or by sulphate, so as to present the lead in the form of a salt capable of regenerating the dioxide; this is done by oxidising it by an alkaline hypochlorite.

The reaction should occur in a medium acidulated by acetic acid, to the exclusion of mineral acids, even in traces. It is also necessary to present the lead in the form of a salt capable of regenerating the dioxide; this is done by oxidising it by an alkaline hypochlorite.

This process gives a crystalline mass, which, in spite of good exhaust, have not been removed. But strong draughts must be avoided, for they cool the furnaces, interfere with the effective action of exhaust hoods for fumes, and stir up any dust which is lying about.

The floor, constructed of plates of sheet iron or Dutch tiles set in cement, should be smooth and kept in good condition, clean and moist. It should be carefully washed, especially in the vicinity of the furnaces, and collections of refuse should be removed at once. Dust should be removed from the furnaces, the walls, and the ceiling either by washing, or, still better, by using a vacuum cleaner. A copious spray of water only serves to stir up the dust. The walls should be smooth, so as to offer the least possible surface to which dust can adhere, and whitewashed, which makes the workplaces more comfortable, lighter, and allows the immediate removal of deposits of dust. Walls can be easily and rapidly whitewashed by a sprayer.

Unloading trucks with the shovel or emptying sacks containing ore causes large quantities of dust, which can be avoided by sprinkling with water. The cleaning and drying of sacks should be done so as to prevent all danger, by beating them in closed apparatus supplied with an efficient exhaust for dust.

The handling of dry lead ashes, lead dross, and debris of white lead, as well as of other waste used in the preparation of lead, gives off particularly injurious dust, because it is finely divided. The transport of these materials to the smelting houses takes place everywhere by means of conveyers, not always closed, and more rarely by means of sacks. Generation of dust should be avoided while emptying and cleaning articles used for conveyance.

Ore should be moistened as it is travelling to the furnace, after crushing, when it is in the small trucks going up the incline. It is advisable that these small trucks should be supplied with covers.

If the ore is kept for the night-shift in receptacles placed at the top of the furnace, the heat dries the ore and favours the liberation of dust when it is put into the furnace. It is preferable to keep the ore in front of the furnace, for in that case it keeps moist a longer time.
Efficient exhaust ventilation for vapours given off during roasting must be maintained. If the installation is not adequate, abundant white vapours of sulphate and oxide of lead penetrate into the workplace; this trouble presents a very serious risk to the health of the workmen. A good draught in the interior of the furnace will prevent any escape of fumes from the working apertures.

The mechanical system, with automatic charging and discharging, has wonderfully improved the hygienic conditions of smelting works. Workmen are no longer exposed, as they used to be, to radiations from furnaces and to risks from fumes and toxic gases.

The same applies to the conveyance of roasted ore to the converters. When the exhaust device acts well and all the apparatus is kept in good working order, no fumes escape from the doors for raking the furnace.

The conditions of the workmen employed in emptying the melting pots are certainly not so good. When the product is split on the ground, it gives off clouds of smoke and dust which completely envelope the workmen and make a bath and thorough cleansing of their clothes a necessity. The smoke contains as much as 10 per cent. lead and it is impossible to moisten the roasted mass, the addition of water having the effect of slaking the lime present in the mass and causing decomposition of the ore. The Sinter process prevents fumes entering the foundry better than other methods do, except, of course, when the exhaust ventilation is defective.

In other cases the roasted mass should be moistened before it is loaded into the trucks. Stokers should be only allowed to go under the fire-bars to clear out the ashes under cover of a strong current of air. The fire-rake should have a long handle. Mechanical cleaning is naturally to be preferred.

The Savelberg process, which is another modification of the Huntington-Heberlein process, is still less dangerous, for this process does not involve preliminary roasting.

The good technical organisation of some works shows once more the beneficent influence which results from the hygienic precautions. The work, for example, in the smelting works of Freiburg in Saxony is essentially mechanical and automatic; and the removal of fumes and dust is assured as far as it is possible.

It must be admitted that in certain cases, for example, at roasting and smelting processes, the introduction of exhaust hoods is difficult to arrange, for they diminish still more the available space, which is too limited as it is. The conditions are particularly unhealthy where several of these furnaces are arranged together in one place.

Reveratory furnaces are not entirely above criticism; the different types of furnaces for roasting and smelting, although less dangerous because they require lower temperatures, all have the same defect: the chimney-stacks are too short and there is not a strong enough draught to carry off effectively the gases and vapours.

Free escape into the air of the workplace of fumes from leadcasting must not be allowed. Incandescent and fuming dross, if plunged into tanks of water, may cause explosions.

The hours of work for the shifts employed on these operations should be limited.

In spite of numerous attempts to improve the process, the crushing of the roasted ore before it passes to the melting furnaces is still laboriously carried out by the use of hammer, chisel, and pick. The ore must be constantly moistened so as to prevent the generation of lead-laden dust. In spite of all precautions, soldering the hands cannot be avoided and an expert has found on them, in spite of thorough moistening, as much as 0.64 grm. of lead. The utmost cleanliness should be insisted upon from these workmen.

Crushing the masses roasted by the Huntington-Heberlein process is a very difficult operation, and reasons have already been given why it is not possible to moisten them before crushing; but whatever the circumstances, moistening ought to be done at the time the ore passes to the furnace.

Workmen employed on crushing should wear respirators; the hours of work should be lessened; work should be alternated with change to employment on less dangerous processes; utmost cleanliness must be insisted upon; old methods must be replaced by the most modern with mechanical crushing; roasting should be done in rotary furnaces which allow the roasted material to be automatically discharged and do not require hand labour for working or transport.

Whereas work at melting furnaces was formerly an important source of lead poisoning, to-day, by reason of improvements in technique, it only represents a cause of secondary importance. But these happy results will only be attained, even with a perfect plant, if every possible preventive measure is adopted.
The roasted and crushed ore is carried in large trucks into the smelting house and emptied on the floor by the furnace; it has to be loaded again, this time into small trolleys which carry it to the furnace mouth, where it is thrown into the furnace. This work, which gives rise to a great quantity of dust, can be made less injurious to health by installing a mechanical feed for the furnace by means of an aerial metal cable. The ore is contained in hoppers which empty themselves automatically, whilst a closing system prevents the escape of gases and vapours. Workmen should be forbidden to take pieces of ore in their hands to put them in the furnace. The question of automatic charging should be carefully studied by the technical management of smelting works, when the work involves roasted material at the upper layer.

Moistening this roasted material when it is rapidly introduced into the furnace is technically possible and has been used for years in Canadian smelting works in British Columbia.

The technical managing staff should prevent the possibility of damage caused by work in front of the lower part of the smelting furnace. All escape of fumes containing lead should be prevented during the discharge of molten metal and liquid dress, all the more so as the tap holes are used several times in the course of a day's work.

Exhaust ventilating hoods should be provided with a strong draught above the channels for the escape of dress, reaching as far as the pots receiving the dress and so arranged that the dust particles do not interfere with work at the tap holes, but should prevent the entrance of cold air which interferes with proper action of the draught.

An exhaust hood should be constructed, luted to the side of the furnace with clay, above the tapping hole for the dross and the channel for its removal. Within the actual hood, opposite the tap hole, an opening for raking should be placed. The hood may be attached to the masonry of the furnace by chains, so that it can be easily raised when occasion requires. The exhaust pipe should open into the flue for the removal of the fumes. A common hood for tap holes is not recommended. Workmen should be forbidden to inspect the exhaust shaft, through the hood, for that exposes them to the effect of gases and fumes, the furnace mouth should be most carefully closed; the charging cylinder should always descend sufficiently deeply into the mouth of the furnace; fumes should be carried off by lateral pipes, connected to an exhaust, which can be easily inclined downwards and open into a dust chamber.

In some important works where a series of pots are placed on a revolving disc, a fan is placed in the exhaust flue. A common hood can then be placed above the tap hole for the dross and independent hoods above each pot receiving the dross.

In order to prevent the escape of fumes during the opening of the tap holes for the lead, while the metal is running, the use of an automatic tap hole, or syphon of the Arent type has been proposed and it certainly limits the escape of fumes.

The withdrawal of fumes ought also to be provided for over the point of exit of the lead, when the workman ladles out the metal material that has been melted or in a special pot arranged at the side, in order to run it then into the mould.

The arrangement of the Caron mechanical flow can only be used in large smelting works. In this system the lead from all the furnaces is collected in a large reservoir and from there directed automatically into the moulds. A single workman is sufficient to supervise the whole operation, which does not expose him to the injurious action of fumes and vapours.

Furnace cleaning for the removal of debris must only be done when the furnace is quite cold and aired. During the removal all crusts should be thoroughly moistened to prevent the raising of great quantities of dust. The work of repairing masonry should only be done after the furnace has completely cooled.

The removal of fumes and dust is certainly a most important thing. Lead fumes escaping from the furnaces become changed immediately on cooling into dust which is deposited on the walls, the ceiling, and the floor. These fumes escape with gases from the furnace mouth, become deposited in the flues and dust chamber, stick to the clothes, hands, and hair of the workmen, and, as the dust is very finely divided, the slightest draught sets it in motion. In old lead-smelting works this dust is found in such great quantities that even clearing it away may be dangerous to health. It is not always possible to collect it at the actual source, and this is why care is necessary to collect it where it is deposited, so as to render it ineffective.

When the temperature of the operations passes beyond the point of vaporisation of lead, which happens fairly often, great quantities of lead vapour are formed, which are not only
an important cause of poisoning, but represent also a loss of considerable quantities of metal, if these vapours are not subjected to condensation.

The surrounding temperature being below the point of their vaporisation, these vapours condense immediately and float for some time in the air; then they descend slowly in the form of a very fine dust, which is of a greyish-blue colour, sometimes the colour being a little lighter. This dust easily becomes diffused in the air and does not take moisture when watered. Only a slow and penetrating watering is of any use; but it is difficult to carry out, for, on the one hand, the dust chambers are of large size, and, on the other hand, there would be a formation of sulphuric acid which ruins the clothes of the workmen whose duty it is to do the cleaning. So it is preferable for the gases from the furnace fire and the fumes to be made to pass into flues and chambers and collected in a large flue leading to the dust chamber.

This installation requires cleaning at regular intervals, an operation which is not without danger for the men; hence it ought to be carried out, so far as is possible, with every protective measure.

The pipes used for the removal of the gas fumes are cleaned by raking with curved hooks. In a smelting works at Ems the cleaning of these pipes, arranged in the shape of a saw, takes place through the lading holes which are on the short side of the bottom plate. A pipe fitted with a funnel, which has a valve, is inserted below them, through which a hook passes and is introduced into the lading holes. The partial cleaning of the flue is thus done without raising dust.

But to clean the larger flues the workmen must enter them, and as it is not possible to moisten the dust, poisonous clouds arise during the operation. This is why recourse is had to burning the dust some time before removing it by suspending in the flue a cage filled with burning coke. The transformed product is, however, still capable of giving off dust, and if the workman passes into the flues before they are cool, he is troubled by the gaseous given off by the still smoking dust.

Many attempts have been made to replace hand work by an automatic process, for it is an urgent matter to render such an unhealthy operation less so. The dust collector, constructed on the model of the Arent dust collector, has given good results. A series of oblique baffle plates, arranged from left to right, are immersed in water in a long rectangular chamber. The fumes enter from below by the small side of the chamber, keeping close to the partitions in making a zigzag course in the water to reach the opposite side, where they are sucked out. The dust thus remains in the water from which it is recovered from time to time. The precipitation of dust and smoke by the electric process of Cottrell (see article "Dust, Fumes and Smoke") is also very useful and gives good results, especially in dealing with strongly acid gases which do not lend themselves to methods of filtration.

Some English and American smelting works make use of filtration chambers placed above the dust flues. These are tall erections in which long cotton bags are suspended; air, drawn from the flue, and still rich in quite fine particles of dust, is aspirated through the sides of the bags; the dust is deposited on the inside and is brought down by shaking by hand, but more frequently by mechanical shaking. It falls through holes in the floor of the building into dust chambers (Beth filters, etc.). (See article "Dust, Fumes and Smoke").

In spite of all, these arrangements only eliminate part of the dangers which threaten the workman. As a matter of fact, these methods have no great practical value if the operations of dust removal and of carrying off fumes are not done mechanically. At large works the search continues for a satisfactory solution to the mechanical problem of dust removal; but whilst it continues, the workmen must be provided with every means of prophylaxis and every facility for combating the dangers arising from this operation, which has to be frequently carried out, especially when the plant is not large.

The chamber must be cooled before emptying; it must be so large and high as to allow the collection and removal of dust easily and be affected merely and without difficulties; the flues must be so spacious as to allow the workmen to stand upright and permit them to manage easily their shovels and trolleys. These flues must be closed during the removal of dust; a canvas shoot at the bottom of the trolley allows the dust to fall gently into the transport trucks, which must be provided with covers.

The working shift must, of course, be very short and not exceed four hours a day as a maximum; but the plant should be so arranged that the cleaning only takes place once a year.

In desilvering works it is necessary to protect the workmen who watch the litharge for the mirror to appear by interposing a protective screen and by insuring good evacuation of the fumes,
as well as by insisting on cleanliness of the workers' hands, which become soiled by handling lumps of lead.

If crushing is done at the works it should be done in hermetically sealed crushing machines, from which the sifted powder falls straight into the receptacle in which it will be removed without the dust being able to escape into the workplace.

During the desilvering process it is often difficult to protect the pots by a hood coming very low, for such an arrangement would obviously interfere with the work. But it is essential to maintain thorough ventilation of the place, as the workmen who have to remove the scum and slag are in all the greater danger, because this work is very hard and they are obliged to lean over the pots.

The Rozan process and certain other systems adopted by large smelting works, ensure conditions of work, excellent both from the viewpoint of hygiene and of economy, for they avoid manual contact with lead from the beginning to the end of the operations.

It may be said that modern technique can apply systems which prevent all escape of lead vapours and fumes and reduce to a minimum danger of lead poisoning from inhalation of lead. It is evident that fumes containing at the same time arsenic and antimony should also be evacuated, and that these measures must be completed by the utmost cleanliness on the part of the men.

Manipulation of working lead also calls for practical measures of cleanliness and dust removal, as mentioned above. It must not be forgotten that the clearing away of lead waste includes also dealing with arsenic and antimony; a risk much more serious and complicated, which it is necessary to limit or eliminate as far as possible. Without repeating here what has already been said above regarding exhaust hoods, it will be sufficient to insist once more upon covering up the channel which conveys the molten metal to the cupellation pot, upon the use of receptacles for collecting the slag and upon measures of cleanliness, etc.

Danger of lead poisoning is particularly serious when open hearths are used.

Working overalls with caps, gloves, and shoes should be provided, and, if occasion requires, respirators, which should be cleaned and have all dust removed every time before use. Particular care should be taken that the workmen who work with shovels wear respirators.

Ordinary clothing should never come in contact with working clothing. It is best to provide for each workman an iron locker, divided into two compartments. Cloakrooms should be located in the part of the smelting works least exposed to dust. Bath rooms provided with sand-soap, brushes, and towels should also be installed there. Workmen should be able to have a bath during working hours. Those who are employed in the removal of dust should take a bath daily, and those who work in other departments should take a bath at least once a week. Attention should also be given to care of the teeth.

Fatigue, which is localised, especially in the muscles of the neck, back, and upper limbs, should be reduced by carrying on the work as much as possible mechanically and automatically. Workmen who are continually on the move, however, cannot show serious localised fatigue, especially when raw materials are moved by means of locomotives, in trucks on inclines, by mechanical elevators, or by endless chains.

Technicians have for a long time past shown remarkable powers of invention in this branch and have still a fertile field for investigation. But it will never be possible to replace manual labour entirely. That is why it is necessary to create and apply the special means of protection described above.

Strict selection of the men on engagement by a thoroughly experienced doctor is of fundamental importance. Every person must be excluded who is affected by tuberculosis in any form, epilepsy, hysteria, neurasthenia, and all kinds of neuroses, as well as any person having a predisposition to mental diseases or alcoholism, or those subject to rheumatism and those with diseased kidneys; for lead poisoning has particularly serious consequences for such persons. These measures may be difficult to apply when manual labour is scarce, but an employer should, in his own interest, not hesitate to dismiss from the industry those whom he will have to discharge sooner or later in any case.

Periodical health inspection should be arranged, which should not be limited to a simple medical examination, but should include a complete examination for all known symptoms which may indicate the early appearance of lead poisoning. Any sick workman should be temporarily suspended from contact with lead and employed in another occupation, or, if
necessary, removed permanently to non-injurious work.

Great sweating caused by the high temperature with consequent dehydration of the tissues, thirst, extra consumption of liquid, which easily causes catarrhs of the digestive system, can only be limited by providing sufficiently large areas in front of the furnaces so that the workmen need not be exposed to the immediate environment of sources of heat. A water supply, protected from dust and easy of access, should of course be provided.

A supply of suitable drinks is also to be recommended (see article "Personal Hygiene").

Instruction of the men should be taken into serious consideration so that they may know how to make rational use of preventive appliances, adopt the layout of their work, and other medical instructions. This education of workmen should be given at the works, not only by the foremen, but especially by the works doctors, according to a fixed scheme strictly carried out.

LEGISLATION

Women are excluded: from the manufacture, melting and manipulation of lead in Argentina; from melting lead and from any process in which lead figures in Great Britain; from casting lead and making sheet lead in France; from work involving the use of lead, from accumulator factories, etc., in the Netherlands and Switzerland; from manipulating any substance or any compound in the dry state containing more than 2 per cent. of lead in Pennsylvania and New Jersey; and in Japan from every place where dust, fumes, or gas containing lead are produced.

Young persons of less than fourteen years are excluded in Belgium from lead-smelting works, from the shops where the smelting takes place, from shot making, and also from works where copper, bronze and lead are smelted; of less than fifteen years in Japan from workplaces where dust, fumes and gas from lead are given off, and from work on ores, and metals where dust is given off very abundantly; in Poland from lead industries; in Italy from the treatment by smelting of argenticiferous ores of lead and from works for the treatment of metallic lead; of less than sixteen years, as well as women, in Argentina; in Greece from factories where lead or its alloys are prepared; in Spain from the manufacture of heavy metals, from dry pulverisation and sifting of ores, from the metallic lead industry, from casting and fitting of articles of lead or of its alloys; in Great Britain from casting melted lead, from lead-smelting works, as well as from any work dealing with the manipulation of lead; in Canada (Quebec) and in New Jersey from any operation in which lead is used; of less than eighteen years in France from casting lead and making sheet lead, even in accumulator factories; in Poland from all operations which require contact with lead; in the Netherlands and Switzerland from work in the preparation of lead; and from accumulator factories; of less than twenty-one years in Pennsylvania from work in the preparation of lead.

Young girls of less than eighteen years in Great Britain, Canada (Quebec), and Greece; of less than twenty-one years in Spain, Italy, Japan, and generally in all the other countries are excluded from the processes mentioned above for young persons.

The First International Labour Conference, held at Washington, 1919, passed a Recommendation concerning the protection of women and children against lead poisoning in consequence of the dangers to women from the point of view of maternity, which certain industrial operations present and with the object of allowing children to develop physically. The Recommendation requires that the employment of women and young persons below eighteen years shall also be prohibited from work at furnaces where reduction of ores of zinc and lead is carried on; from lead smelting, and also the smelting of old zinc; from the manipulation, treatment or reduction of ashes containing lead and from the desilvering of lead; from making solder and alloys containing more than 10 per cent. of lead; and that the employment of these persons on work where salts of lead are used shall only be authorised on condition that the following measures are adopted: ventilation so placed as to remove dust and vapours as soon as formed; cleanliness of tools and workplaces; notice to be given to the public authority of every case of lead poisoning, and persons affected by poisoning to be compensated; periodical medical examination of persons employed on the work under consideration; installation under satisfactory conditions of cloakrooms, lavatories and dining-rooms; provision of special protective clothing; prohibition of the introduction of food or drink into the workplaces.

The Conference, on the other hand, recommends, in industries where it is possible to replace soluble salts of lead by non-poisonous materials, that use of the said soluble salts of lead should be the subject of the strictest regulation. Any salt of lead is considered as soluble which, as regards more than 5 per cent. of its weight calculated as metallic lead, is soluble in an aqueous solution of hydrochloric acid with a strength of 0.25 per cent. of acid.

A long series of provisions have been laid down by the legislatures of various countries regarding the hygiene and protection of workmen employed in smelting lead.

Thus, for example, in Germany according to section 16 of the Factory Act (R.G.O.) the working of all smelting works is subject to the previous permission of competent authorities. According to section 139 (b) of the same Act, the inspector
requires the application of measures necessary for the protection of the lives and health of the workers.

The Prussian Decree of 1904 even provides for a preliminary examination of plans for new works, or of those undergoing reconstruction (opinion of civil engineers, the factory inspector, and the medical officer of health).

The German Order of 16 June 1905 lays down measures on the setting up and working of smelting works (according to paragraph 120 (e) of the Factory Act (R.G.O.) and particularly those with smelting processes. This very detailed Order lays down the dimensions of the workplaces, the ventilation, the removal of dust, instructions regarding the floor and walls; the provision of drinking water near the furnaces and cauldrons; the covering in of crushing machines and the removal of dust from sacks; the moisturizing of material, except the roasted mass from the converters; the collection of dust, fumes, gas, and vapours, and their removal mechanically, or by other efficient means, by casing, screening, sifting, or melting. Adequate sealing, and constant supervision of joints to prevent any escape of vapours, gas or dust; opening of apparatus only to take place after dust has been deposited and cooled. Special authority is to be required when it is desired to set up furnaces for the distillation of zinc from the lead oxide, provision drawing the attention of workmen against the damage which gases, vapours and dust may cause. Workmen employed in removing dry dust from the interior of dust chambers or flues must not work longer than four hours a day. They must also wear suitable clothing, caps, and respirators.

If soluble salts of lead are to be handled, some greasy substance should be issued for rubbing over the skin of the hands and face, or impermeable gloves should be employed. Douché baths, lavatories, cloakrooms, and dining-rooms must be provided and care taken to see that the men use them.

A monthly medical examination is laid down by German legislation; and the results of the examinations are entered in a health register. The Ordinance of 27 January 1909 does not apply to lead-smelting works, even if they make lead compounds or lead colours. Nevertheless, an admonition is given to bear in mind the instructions which are enumerated therein. According to the Prussian Decree of 9 April 1921, the district medical officer is the most suitable person to supervise the hygienic and health conditions of smelting works; he submits his reports to the consulting medical inspector of factories.

In Austria lead-smelting works come under the Ordinance of the Federated Social Ministry of 8 March 1923, which lays down rules for the protection of the lives and health of persons engaged in lead and zinc-smelting works and zinc-white factories. This very detailed Ordinance lays down measures for the starting of new works and workshops in general, as well as measures for their actual working.

It provides for the number of hours of work daily in different sections of the works, for measures of personal hygiene, as well as for supervision of the health of the workmen by medical certificate on engagement, periodic medical examination, exclusion from processes with a danger of lead poisoning of persons specially sensitive to the action of lead; for examination for lead in the air of the workplaces by qualified experts, in special cases, and for the posting up of a warning notice for the workmen.

Regulations adopted 19 November 1925 by South Australia for the prevention of poisoning by lead and by carbon monoxide, provide for posting up, as well as distributing to each person employed, a notice drawing the attention of workmen to the risk of lead poisoning and poisoning by carbon monoxide. Each case of poisoning, if only suspected, should be notified to the factory and workshop certifying surgeon. The Regulations provide that lead material shall be so moved and stored that no vapours, dust, or gas is generated. The Regulations also lay down preventive measures for persons who enter furnaces, or dust chambers; and measures concerning ventilation, personal hygiene, wearing of respirators, dining-rooms, lavatories, and douche baths. In New South Wales the work of mines and smelting works is regulated by the Mines Inspection Act of 1911, section 48. Western Australia also adopted preventive measures against lead poisoning in 1925 (Ordinance of 30 January). In Tasmania the regulations for mines and industries date from 1915.

In Canada (British Columbia) regulations have been drawn up by the Consolidated Mining and Smelting Company of Canada.

In France the special regulations concerning the particular measures of hygiene applicable to industries where the personnel is exposed to lead poisoning (1 October 1913) deal, among other matters, with lead metallurgy, the cupellation of argentiferous lead, and the making of alloys of lead. In addition to measures of a general kind, it must be mentioned that cauldrons should be placed in an airy place separated from the other workshops. Exhaust hoods or other efficient arrangement for the removal of fumes must be installed: (a) above the tap-hole for lead and slag in the industry of the metallurgy
of lead; (b) in front of the furnaces in the industry of making oxides of lead; (c) above the melting pots for lead or its alloys in the other industries enumerated in the first section of the Order.

In Great Britain regulations are provided by the Act of 1911, No. 752, and by that of 8 November 1921. The Order of 23 December 1920 dealt with the better protection of women and children against lead poisoning, whilst that of 31 March 1922 deals with certain processes with a risk of lead poisoning in the India-rubber industry.

In India the Indian Factory Act of 1911 regulates work in mines and smelting works.

In the United States, the State of New York enacted in 1915 measures for the removal of vapours, gas, and poisonous dust; the State of New Jersey also made provision in its "Standard 1911." An Order on the lead and copper industries dates from 1914.

Norway enacted an Act dated 30 October 1919 containing hygienic regulations for lead-smelting works.

In Rhodesia regulations have been drawn up by the Mining Society.

In Russia the law takes into consideration work in the industries of copper, silver, and lead, and in general all work which causes contact with lead.

Sweden has published some Memoranda for lead smelters.

Some detailed measures are laid down by the legislature in Yugoslavia in the Regulations on the hygiene of work of 25 October 1921 (sections 135 et seq.).

A monthly medical examination is laid down for lead smelters in Germany, Austria and Great Britain; quarterly in Austria and in Yugoslavia for workmen at lead-smelting works not employed in smelting; annually in Austria for lead workers and those who make lead articles; without laying down any period in Czechoslovakia for workmen in lead industries. Cataract among smelters is compulsorily notifiable in the Netherlands. Cases of sickness caused by lead poisoning among lead smelters are compensated as accidents in the countries which are given in the article "Lead Poisoning".

Russia also compensates for cataract among lead smelters.

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The illustrations are from drawings and photographs published by the author in his article on lead-smelting works in Bd. 1 of the Handwörterbuch der soz. Hyg. von GROTHAUN and KAUF, Leipzig, Verlag F. C. W. Vogel, 1912.

Dr. O. Frey
(Berlin).

Lead Colours


CHEMISTRY

Lead colours can be classified as White (white lead, sulphate of lead, etc.); Yellow (Cassel yellow, iodide of lead); Red (red lead, chrome red, litharge, Brunswick yellow, English yellow, or patent yellow) is an oxychloride of lead, and like the iodide is very little used. Naples yellow or antimony yellow is a compound of antimoniate and oxide of lead, used especially in the ceramic industry.

The neutral chromate of lead is found in the natural state as crocoite; it is prepared artificially by precipitating a solution of acetate or nitrate of lead with potassium. It is a heavy powder, golden yellow in colour and insoluble in water. The basic chromate of lead (or chrome red) is made by treating the neutral
chromate with an alkali. Orange chrome is a mixture of these two chromates.

These chromates are usually mixed with foreign substances and especially with sulphate of lead, which is produced, at any rate in part, in the process of manufacture.

USES

They are used as oil colours, lacquers, and varnishes in the painting industry and all industries using colours (ceramic pottery, manufacture of coloured papers); in the textile industry (mordanting, finishing, dyeing), and principally in the cotton industry. The colour is fixed in the fibre which has been previously steeped in a solution of a lead salt, and then treated with a solution of chromate, and finally with an alkaline solution to give it a reddish tone.

DANGERS

The manufacture of lead colours exposes the workers to the same dangers as other lead industries (red and white lead, etc.). The operations of mixing, grinding, and packing should be done in such a way as to reduce to a minimum the raising of dust, by adopting either hermetically closed apparatus with efficient exhaust ventilation, or exhaust hoods locally applied to the bins and boiling vessels. Wherever possible the material should be damp. With chromates of lead danger presents itself also at the time of boiling, because the steam carries up with it minute particles of chromate of lead. This process must therefore be carried out under an exhaust hood. Pressing the cakes of chromate should also be done in a moist state; it can easily be shown that the hands, arms and clothes of the workmen are nevertheless covered with a thickish layer of pigment.

The danger from chrome green is limited to the dust given off during dry grinding—a process generally carried out in closed apparatus under negative pressure. Grinding the colours in oil should be carried out under the best conditions possible (see article "White Lead"). Similarly, in packing the aim should be to protect the worker by ensuring the least possible contact with the poisonous substance.

The danger in dyeing with lead compounds has been emphasised by Koelsch and Ilzhoefen (1925); cases of lead poisoning have been noted amongst furriers who made imitation chinchilla by treating skins by acetic of lead and ammonium sulphide.

STATISTICS

The frequency of cases of lead poisoning from colours and varnishes is closely bound up with the hygienic conditions of the workrooms and the personnel. In Great Britain the reports of the Medical Inspector of Factories show the following figures in triennial periods:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1909</td>
<td>561</td>
</tr>
<tr>
<td>1910</td>
<td>171</td>
</tr>
<tr>
<td>1913</td>
<td>9</td>
</tr>
<tr>
<td>1921</td>
<td>8</td>
</tr>
<tr>
<td>1925</td>
<td>10</td>
</tr>
</tbody>
</table>

(The raised figures indicate deaths.)

SYMPTOMS

(See article "Lead Poisoning"). Lesions of the skin occur not infrequently, mainly as a result of the action of the chromates (see article "Chromium and Chromates").

HYGIENE

The same measures on which stress has been laid for white and red lead and lead compounds come into play here (see those articles).

LEGISLATION

Austria. Regulations of 15 April 1908.
Canada (Province of Quebec). Regulations on the packing of lead colours, 1909.
France. Ministerial Decree of 1 October 1913.
Germany. Regulations of 27 January 1920 (see article "Lead Compounds").
Great Britain. Regulations of 21 January 1907: requiring locally applied exhaust ventilation, periodical medical inspection, etc.
U.S.S.R. Regulations of 11 October 1924.
Switzerland (city and surroundings of Basle). Regulations of 27 June 1914.
Western Australia. Regulations of 22 December 1923.

These regulations comprise the removal or absence of poisonous dusts, the exclusion of women and children, medical examination on the commencement of work and periodically afterwards, and welfare provisions common to all unhealthy industries.

The exclusion of adult women is required in Argentina, Germany, Great Britain, South Africa, certain States of America (e.g. New Jersey and Pennsylvania). Young persons under 15 are excluded in the State of Delaware and in Japan; under 16 years of age in the majority of the States of America and in Argentina, Germany, Greece; under 18 years of age in Great Britain, Norway, Netherlands, Poland, South Africa, Switzerland, etc. Boys under 15 are excluded in Italy; under 16 in the Province of Quebec (Canada) and Spain; female young persons under
18 years in the Province of Quebec and in Greece; under 21 years in Italy and Spain. (See also articles "Lead" and "Red Lead ".)

The periodic medical examination takes place monthly in Belgium, Great Britain, Illinois, Missouri, New Jersey, Ohio, Pennsylvania; fortnightly in Germany; quarterly in Austria, France, and Yugoslavia.

For the notification and compensation for industrial diseases, see the articles "White Lead" and "Lead Poisoning".

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**Lead Compounds**


Among the compounds of lead which deserve special mention are the following:

(a) Arsenate of lead, very toxic and very often used in agriculture as an anti-parasiticide and even scattered from aeroplanes for the purpose of disinfection of forests (see article "Arsenic"); recent particulars of several cases of poisoning are known;

(b) Chromate, used especially in dyeing cotton, wool, wood, etc., although there are numerous non-toxic colours available which can replace it (see article "Lead Colours");

(c) Sulphate (Pb SO₄ with 73.61 per cent. of lead). This occurs in nature in the form of rhombic crystals (anglesite) or it can be obtained by precipitating solutions of lead by sulphuric acid. Lead sulphate had long been thought to be non-toxic as it is almost insoluble in water; but researches dating from 1904 have shown that it is soluble in diluted hydrochloric acid as well as in solutions analogous to gastric juice; and even in gastric juice itself. Goadby has shown experimentally that it is even more soluble than the carbonate (white lead) and the oxide (litharge). The presence of peptone in the gastric juice is said by Blum to increase, although in minimal degree, the solubility of lead salts. Carlson and Woelfel (Chicago) have also investigated this subject and concluded, after a long series of experiments, that the sulphate is toxic, and that none of the regulations directed against prevention of lead poisoning may be omitted in the case of sulphate of lead.

(d) Sulphide. This is interesting both on the practical and theoretical side. In its natural state the sulphide occurs as galena which never exists pure, but contains cerussite, lead, silver, antimony, mercury, and other substances. Statistics relating to several thousands of workers in the mines of Pribram, and recorded over a period of ten years, tend to show complete absence of evidence of cases of colic and only a few of gastritis and constipation. Investigations by Biondi and Frongia (1907), however, in the Sardinian galena mines, employing hundreds of workmen, brought to light the frequent occurrence of affections with a clinical picture resembling slight plumbism. Thus, in addition to symptoms of lead absorption (blue line, punctate basophilia, constipation), they detected traces of lead in the urine. Symptoms of genuine lead poisoning were exceptional (colic, neuritis, encephalopathy), although formerly they had been reported by a practitioner in the district. Possibly improvements in the industry or in the conditions of the workers had resulted in lessening the power of the toxic substance to affect the system.

Frongia examined 456 workers engaged in sorting and washing the mineral and found that it had a noticeable effect on the functions of the sexual organs: arrest of the development of the signs of puberty, disorders of menstruation, sterility, etc., all of which signs he attributed to the action of lead as they affected the subjects of chronic plumbism.

Galena, which sometimes contains mercury (e.g. in Sardinia from 0.5 to 3 per cent.), may cause mercurial poisoning among furnace workers from evolution of mercurial vapour.

Hamilton also cites cases of lead poisoning among some workmen employed in a galena mine in the United States (25 cases in 1912).

Lead sulphide in a pure state is considered as harmless by Rambousek in view of its almost complete insolubility in water.

Teleky and Biondi do not agree with this view, although they admit that very little of the pure compound can be absorbed and that it must be, therefore, relatively very slightly toxic. Investigations by Murgia, however, in 1911 have shown that it is absorbed and quickly eliminated in the urine. Toxic signs are to be observed, but they are slight. Carlson and Woelfel of Chicago have also investigated this subject. Their conclusions are that sulphide of lead is soluble in human gastric juice; that its solubility is less than that of the basic sulphate.
and basic carbonate of lead, but that it is sufficient to endanger the health of men employed in galena mines and in manipulating the material if dust is raised in the process, and, finally, that these workmen should be protected against the risk of lead poisoning as much as any others.

Among the *organic metallic derivatives* of lead, tetra-ethyl is the most important (see that article).

A chemist was engaged in preparing *lead bromide* by making potassium bromide react on acetate of lead in an acetic solution when there occurred a violent explosion during grinding in a mortar. The chemist, ignoring the fact that this reaction caused formation of a compound very sensitive to friction, i.e. a double bromate of acetone and lead, fell a victim to its effects.

The chemist, ignoring the fact that this reaction caused formation of a compound very sensitive to friction, i.e. a double bromate of acetone and lead, fell a victim to its effects.

Mention only need be made of the following compounds: acetate (Pb(C₂O₄)₂ + 3H₂O) is commercially obtained by dissolving litharge in acetic acid, or by the reaction of acetic acid and air on lead. It is used specially as a mordant and for the preparation of different salts and lead colours. The basic acetate is used to impregnate the textile fibres (especially silk), in the manufacture of white lead, of acetate of aluminium, in tanneries, etc.; chloride (PbCl₂) which is given off under certain conditions as a vapour in some industrial processes, as e.g. "tinning" of kettles and saucepans; sesquioxide of lead (Pb₂O₃); peroxide (PbO₂), used in the accumulator industry and the manufacture of matches; nitrate; iodide; silicate (see article "Pottery Industry"); nitrate (see article "Explosives"), lead tungstate used in rapid-drying paints, and more recently lead selenide used in rubber compounds to increase resistance to abrasion.

**TOXICITY**

(See article "Lead Poisoning.") Noteworthy is the apparent extreme toxicity of lead tetra-ethyl, as judged by the number of persons poisoned in the Standard Oil Petrol plant, New Jersey (1924), which may be explained by the extremely fine state of division of the lead.

**SYMPTOMS**

(See the same article.) In the cases of poisoning by lead tetra-ethyl the symptoms mainly affected the central nervous system (excitement, delirium, convulsions, insanity).

**HYGIENE**

The measures set forth for the protection of workers in white lead, red lead and litharge factories are also appropriate for other compounds of lead. The materials should be deposited in covered receptacles, or under conditions preventing the escape of dust into the workroom. They should not be manipulated or packed except under conditions preventing the escape of dust or facilitating its removal by exhaust ventilation as near as possible to the point of origin. Processes should be carried out as far as possible by mechanical means in closed apparatus provided with adequate exhaust ventilation for the removal of dust and fumes. These compounds, if possible, should be handled in a moist condition.

All possible measures should be adopted to ensure hygienic conditions in the premises (impermeable floors, etc.) and the welfare of the worker (washing accommodation, baths, cloakroom, working clothes, etc.).

Workers should be medically examined before employment and periodically afterwards. (In Great Britain in white lead works this visit is made weekly; in other lead industries either monthly or quarterly; in Germany bi-monthly; in Belgium monthly, as is also the case in Illinois, Missouri, New Jersey, Ohio, Pennsylvania; in Austria, France and in Yugoslavia it takes place quarterly.) On the subject of notification and compensation, see the articles "White Lead" and "Lead Poisoning".

**LEGISLATION**

The regulations in Germany, for compounds of lead (27 January 1920) relate to acetate, chromate, peroxide, sulphate and other lead compounds; those of Western Australia (22 December 1923), Victoria (12 November 1923), and New South Wales (31 May 1929), to factories manufacturing or handling lead compounds; those of Belgium (5 November 1910) to chromate, oxides and other lead compounds generally. The English regulations (23 August 1921) cover acetate, nitrate, sulphate and lead compounds in general. Regulations dealing with the same class have been made in France (1 October 1913), in Russia (31 March-13 April 1913), and in certain States of the U.S.A. (Illinois, New Jersey, Ohio, Pennsylvania, etc.).

As regards exclusion of women and young persons, see the articles "White Lead", "Red Lead", and "Litharge". See also articles "Silver", "Pottery Industry", "Enamels", "Canning and Food Preserving Industries", "Lead", and "Zine".
Lead Poisoning
(Plumbism or Saturnism)

French: Intoxication par le plomb or Saturnisme. — German: Bleivergiftung. — Italian and Spanish: Saturnismo.

The morbid changes caused by lead and its compounds in the body are generally called "plumbism" or "saturnism".

Sources of Poisoning

Although certain writers have drawn up lists of industries and processes in the course of which lead poisoning may occur (Layet gives a list of 111; Gilman Thompson one of 150), it is wisest not to draw up a detailed list because every day in industry toxic substances are being replaced by others less clear non-injurious; and, on the other hand, toxic substances are being introduced into processes hitherto considered harmless. Thus recently (1924) the manufacture and even the use of lead tetra-ethyl (added to petrol for motor engines with the object of avoiding misfire and as an "anti-knock") has already set up lead poisoning among those who manufacture it and also among garage workers and chauffeurs.

Lead poisoning is an occupational risk to workpeople employed in the extraction, melting and manipulation of metallic lead, and in manufacturing or using its compounds.

Besides metallic lead, lead alloys (with antimony, tin, brass, bronze, etc.) must be taken into account, and, in addition to lead compounds, lead colours largely used in the varnish and lacquer industry, etc.

Lead and its alloys expose to risk of lead poisoning workers engaged in the following processes: the extraction of lead from the minerals which contain it; the preparation and working of metallic lead and its alloys; the demolition of metal constructions (battleships; during cutting up; by means of an oxyhydrogen blowpipe, of lead plates; burning of paint, etc.); accumulator factories; in the making of cutlery, emery wheels, electric lamps; type casting; in diamond and jewellery polishing; in making lead wire capsules for bottle, copper instruments, in dental work, etc.; as well as plumbers, file cutters, welders, tinsmiths, framemakers, etc.

The handling of lead compounds (acetate, chromate, chlorides, oxides, etc.) exposes a great many workers in a number of industries to the risk of lead poisoning; among these might be mentioned the manufacture of lead compounds (see that article and "Tetra-Ethyl Lead"), of colours, varnishes, lacquers, dyes, paper, enamels, ceramics, coach painting, house painting, etc.; engraving; hide, skin and leather industry; making of rubber, glass and mirrors, artificial stones, matches; work in many chemical factories; in the textile industries; making of artificial flowers, lace, etc.

It is also of interest to recall certain rare sources of lead poisoning such as: packing leaden figures covered with a lacquer (Bleyer, 1906); the handling of lead seals by a customs house officer (Mannkopf, 1891); polishing garnets (von Jaksh); handling amber (Schuler, 1902); cigar-making work effected on a leaden table (Pel, 1897); polishing precious stones (Grossmann, 1907); marble polishing using a mixture of wax, alum, sulphur and metallic lead (Schrakamp, 1903); besides the case of a telegraph operative working with accumulators and especially Leclanché elements; and that of an asbestos weaver using lead threads (Netolitzky, 1897), etc.

The degree of risk varies very much according to the technical organisation of the factories, the methods of work, not only for the different lead industries, but for the same industry and in the same country. Despite this fact, an attempt has been made to classify, according to the degree of risk, lead industries and processes; and this classification, based on British experience between 1900 and 1918, would comprise in decreasing order of gravity the following industries: white lead works, manufacture of pottery, coach-painting, smelting of metals, painting and application of colours in industries other than coach- and ship-painting, accumulator factories, colour and varnish factories, soldering, printing, file cutting, and manufacture of red lead. The reports of the medical inspectors, however, in 1919 and 1920 alter this classification, placing accumulator factories first, followed by smelting of metals, white lead and pottery works.

German experience (Wachter, 1908) adopts the following order: manufacture of white lead, red lead, lead piping and lead shot, painting operations, lead and zinc smelting, and letterpress printing.

In the United States, Hamilton and Gilman Thompson place lead smelting first, followed by manufacture of white lead, electric accumulators, pottery, etc. Hayhurst, on the other hand, places the manufacture of electric accumulators and other electric apparatus first, followed by coach-painting, pottery,
white lead, paint and varnish factories, etc.

TOXIC ACTION

Lead and all its compounds are toxic, and it seems of little use to discuss which of the compounds is the most poisonous. Certainly, the more soluble the compounds the more poisonous they are, and the finer the state of subdivision in which they find themselves, the more readily dissolved they are in the organic juices whence they undergo more rapid absorption. Lead and all its compounds, even the insoluble compounds, are absorbed through the alimentary canal. The mechanism by which this is effected is not yet well understood, but the fact is proved by experience. Absorption takes place also by other channels — certainly through the respiratory tract, although in the case of inhalation of lead dust, an important rôle is played by the intestinal tract, following ingestion of the dust inhaled. Probably also, although there is no absolute proof of it, lead is absorbed through the skin, but this channel is practically of little importance.

Certain authorities (mainly British) consider that lead enters the system principally through the respiratory tract, the digestive tract playing a comparatively unimportant rôle. Others, on the contrary, regard the digestive tract as the principal channel of entry and support their view on the experimental fact (Lehmann, Saito, etc.) that only 12 per cent. of the lead dust reaches the lungs, while 70 per cent. enters the digestive tract. Evidently a large quantity of the dust inhaled by the nose and mouth deposits itself on the moist mucous membrane and is removed in blowing the nose or is to a large extent swallowed with the saliva. Whatever be the truth, this discussion, from a practical point of view, is only of secondary importance;

1 There is present in the system of the average individual small traces of lead, derived from drinking water, foodstuffs, and even the dust in the air. During its deliberations the British Committee on Tetra-Ethyl Lead (1926-1930) effected systematic research for lead in the urine of a large number of persons. This research revealed that normal urine always contains a small proportion of lead: 0.040 mg. per litre (average of fifty-five samples). Persons living in the country showed the presence of lead 0.023 mg.l than town dwellers (London: 0.049 mg.). Those exposed to the lead risk showed a higher content: 0.38 mg. These various figures correspond to the returns previously furnished by American and Australian authors. The data concerning workers in accumulator factories are particularly suggestive: founders, 0.059 mg.; fitters, 0.02 mg.; welders, 0.34 mg.; dressers, 0.35 mg. per litre.

the campaign should be waged against the real enemy — dust.

The medical sub-committee which studied the problem of lead poisoning (from white lead) at the International Labour Conference at Geneva (1921) expressed the opinion that “in so far as concerns painters, by far the most important danger is from dust which enters through the nose and mouth. Penetration of lead directly through the skin is without any practical importance, but in many ways lead can be deposited on the skin and be carried thence to the mouth.”

A characteristic of lead and its compounds is to act in very small doses. Though it may be true that the largest part of the substance introduced into the organism passes out without being absorbed and that its assimilation is relatively difficult, its elimination, on the other hand, is very slow. The rather paradoxical opinion has even been expressed (Brouardel) that the toxicity of lead and its compounds is so much the greater the smaller the dose absorbed. Cases of fatal poisoning by a single dose of a salt of lead are very rare.

There is difficulty in determining the dose capable of setting up chronic poisoning, but very small doses renewed daily suffice, even if their total sum does not reach the amount necessary to occasion acute intoxication, assimilation being much more complete.

The dose calculated by Legge and Godby as capable of setting up chronic plumbism is 2 mg. inhaled daily in the form of dust; by Teleky as 1 mg. daily over a period of several months. A dose of 10 mg. sets up very severe toxic symptoms in a short time. According to experiments by Lehmann (1924) on small animals extending over several years, the toxic effect was apparent as soon as 10 mg. of lead was given daily per kilo. weight for two or three months.

Lehmann (1925) considers that under the most favourable conditions the amount of lead absorbed in colour factories per day per workman is up to 2 mg. and under less favourable conditions from 5 to 10 mg. In his enquiry he found from 0.3 mg. to 3.8 mg. per cub. metre of air (results of 12 analyses) and an hourly deposit of 0 to 5 mg. of lead per cub. metre when the conditions were very good (in a white and red lead factory); from 6 to 10 mg. when the conditions were good; over 20 mg. when they were fair. He considers 40 to 60 mg. as the greatest permissible limit (in special cases he found as much as 300 mg.).
Absorption is favoured by several circumstances such as heat, sweat favouring solution of lead oxides, and also by certain food (acids, salads, etc.). Nowakowski (1931) is of the opinion that the biological reaction of the human organism varies in accordance with the seasons; this would explain the variations in the number of cases of lead poisoning which he has noted amongst certain categories of workers exposed to lead risk.

Lead exerts an effect on metabolism now definitely proved. It enters into combination with the albuminoids of the living cells and gives rise to albuminates and protein compounds of lead which are eliminated with difficulty, and which, as they leave, carry away the cell where they were formed. Knowledge at present fails as to the form in which lead circulates in the organism, but there is proof that it can always be recovered in the blood serum.

The experimental researches of Tscharny into metabolism during lead poisoning provides the following conclusions: diminution of the alcaline reserve of the blood with acidosis; diminution of acid-soluble phosphoretted compounds and premature increase of lipoidal phosphorus; substitution of lead for calcium: retention primarily of lead in the bones, which is accompanied by hypercalcaemia and increased elimination of calcium in the urine; diminished elimination of uric nitrogen, followed shortly by retention of nitrogen in the blood, accompanied by abnormal starch reduction in the nitrogenous compounds. Lead poisoning thus produces, prior to anaemia, forms of colic and paralysis, quantitative troubles and desaggregation of nitrogenous substances and elimination of nitrogenous compounds.

According to Schmidt, lead is not only a powerful poison of the cell nucleus, a specific irritant of the haemopoietic organs (of the bone marrow in particular), but exerts a destructive influence on the elements of the circulating blood and is the principal cause of the different lesions found in the various organs and tissues as an effect of its accumulation and of its specific action on the walls of the capillaries: retina, kidneys, intestines, nervous tissue, etc.

Schmidt has also shown that lead is found in the blood principally in the leucocytes, in less quantity in the red blood cells, and still less in the serum.

According to recent research (Scremin, 1924) it would seem as though lead introduced into the system was converted into phosphates which as such are deposited by the blood in the tissues; phosphates being only slightly soluble, the quantity of the soluble lead substances is certainly very small. This fact should be borne in mind in understanding the very slow development of toxic signs in lead poisoning.

The localisation of lead in the different tissues and organs has given rise to difference of opinion among various authorities and it seems to vary according as the poisoning is acute or chronic, and whether of long standing or recent. In addition to the "normal lead" introduced into the system every day, which A. Gautier estimates at 0.5 mg., different investigators have found in the organs and tissues of victims lead located especially in the hair, the nervous system (marrow, spinal cord, brain), the lungs, the liver, the heart, the kidneys, the spleen, the bones, the cartilages, etc.

The largest amount is said to be found in the reticulo-endothelial system.

As has been said above, a large proportion of the lead dust absorbed through the digestive tracts is expelled with the faeces without having undergone notable change. The soluble substances or those which can be made soluble on contact with organic liquids are eliminated more slowly.

The emunctories in decreasing order of importance are the bile, the urine, the saliva, and the skin. It should be remembered that a portion of the lead excreted by the bile in the duodenum is again absorbed by the intestine.

The kidney is one of the emunctories which is most rapidly and seriously damaged by the passage through it of lead, and its damage favours saturnine impregnation of the organism as well as accumulation of toxins. Elimination by the urine goes on even for years (15 to 20) after all contact with the toxin has ceased. Administration of iodine can increase and sometimes speed up the elimination.

Amongst chronic victims of lead poisoning the administration of very small doses of lead causes increased elimination of lead by way of the mouth and re-appearance or accentuation of the Burton line or marking of the gums, etc. Baader considers that this fact should be interpreted as an active mobilisation of the lead and that it is necessary to recognise therein proof of the outbreak of important visceral reactions amongst lead patients. This fact also proves the danger of bringing into contact with lead a worker who has already suffered from serious attacks and that a serious relapse may be feared on resumption of work, even for a short duration.
and with due precautions as regards hygiene.

For some time past distinction has been drawn between "absorption of lead", "impregnation" and "poisoning". By absorption is meant the first stage of poisoning, the toxic substance not having so far produced important changes; by impregnation, the second phase with organic changes sufficiently developed as to be detectable on medical examination and not to be regarded as insignificant; by poisoning, the last phase with signs of the reaction of the organism to the poison manifested in typical lesions, but still a phase at times without very clear symptoms and notoriously without realisation by the individual that he is ill.

Although it can be logically held that once absorption of lead in the organism has taken place, lesions, however slight they may be, may be present in certain tissues or organs, this does not justify application of the term "lead poisoning to the condition simply because signs of absorption are present. Once this is considered, a definite limit exists between "impregnation" and "poisoning" — a thing difficult to allow, especially because it may lead support to the view that the condition of absorption is a condition without importance.

The problem of resistance to lead has not yet been properly determined. It seems, however, to be now commonly recognised that, though there are apparently individuals who, when exposed to absorption of lead, are capable of not presenting the usual clinical picture of lead poisoning, it is not so far known if such persons possess natural or acquired immunity. In the first case, what is the form of immunity? In the second, what is its mechanism? What is certain, however, is that acclimatisation to lead has been definitely proved in animals and that this result has in no sense been due to insufficient absorption of the metal because the presence of lead has always been controlled in the urine. The mechanism by which an acquired immunity has been the subject of several hypotheses — all of them rather vague — and it has not been thought necessary from the practical point of view of industrial hygiene to insist too much on this phenomenon. Whatever the truth may be, lead workers, especially after a short period of work, become specially susceptible to the action of lead (Teleky).

Neither age nor race is a protection against lead poisoning. So far as concerns the slight incidence of poisoning among young people, it has to be remembered that not many of them are to be found in factories and workshops where there is exposure to the risk of lead poisoning. The relative immunity of children, advanced by some writers, must be absolutely denied. As regards sex, while English opinion inclines to the view that women are more susceptible to the action of lead than men, this is not accepted by German writers, who consider that their poor state of nutrition, personal and industrial fatigue, added to housework, long hair and type of clothing favouring the accumulation of a greater quantity of the poison upon them, are sufficiently potent factors to account for the apparent disparity. Data from the United States are not sufficient to allow the experts to support either of these views. All, however, agree that in women lead poisoning assumes a more severe form (manifesting itself in convulsions and amaurosis, etc.) than in men. Further, menstrual troubles are also very frequent.

Similarly, the baleful influence of lead on the foetus is well known. It is not necessary for the mother to be affected by lead for the children to develop symptoms of lead poisoning. English, German and French data show the frequence of miscarriages, although in certain cases it may be difficult to ascribe them all to lead. The wives of workmen in lead industries also present a large number of miscarriages, but though English, Italian and German data are definite on this point, American data, on the contrary, are scarce and rather contradictory. It is useful however to remember that Bedson has found lead in the liver and kidneys of infants whose mothers suffered from plumism.

Other factors are of moment: the precise occupation itself for poisoning is accelerated in proportion as the occupation involves greater exposure to the risk and the dose absorbed is augmented; the habits of the subject, bad habits having an indisputable effect on initial and subsequent attacks; those affected by lead show a characteristic weakness for alcohol and alcoholic beverages; constitutional diseases and all causes of weakness (alcoholism, tobacco, etc.). Though
alcoholism and plumbism may co-exist and induce a kind of hybrid symptomatology, and though alcoholism predisposes the workman to fall a victim more readily to lead, the conclusion should not be drawn that every lead worker is an alcoholic.

Syphilis, it should be remembered, brings about lesions in the same organs as lead poisoning does, so that lead encephalopathy is hard to distinguish from cerebral syphilis. Tuberculosis is also a sufficiently common condition for old subjects of plumbism, and to-day the former view of an antagonism between the two maladies cannot be admitted.

Hereditary lead poisoning does not unfortunately require to be proved. It is admitted that lead disturbs profoundly, not only the function of maternity, but medical sub-committee of the International Labour Conference, Geneva, 1921) expressed the opinion that the statistics are vitiated as to mortality by the exclusion of cases of death due to saturnism which are grouped under other headings, and (b) secondarily by the inclusion under saturnism of cases of death due to other causes. Generally authorities agree that statistics of industrial poisoning have been and always are very far from giving an exact review of the health conditions of an unhealthy industry. The medical sub-committee referred to added that "obligatory notification by a medical practitioner of suspected cases of saturnism, and the certification of these cases by an independent medical man appointed by the State, would provide (as is now the case in certain countries) satisfactory statistics".

The introduction into industry of mechanical or automatic methods reducing more and more contact of the workman with the poisonous compound, replacing the old dry processes by wet, wider substitution of harmless or less dangerous substances for lead compounds in certain industries or industrial processes—these all undoubtedly diminish the number of cases of lead poisoning. Although, however, the severity of the morbid appearances has been much lessened, it does not follow that the lead poisoning has decreased or that there is any reason to make light of the extent and importance of the clinical condition known as slight plumbism.

Sufficiently detailed statistics relative to different industries exposing the workers to the risk of lead poisoning have been given in the articles "Painting Industry", "Printing Trades", "Lead", "White Lead", "Red Lead", "Accumulators", "Pottery Industry", etc. Thanks to the compulsory notification of all cases of lead poisoning arising under Dutch law, 1911, the English Factory and Workshop Act, 1895, and the French Act of 1919, very valuable information is available as to the frequency, the symptoms and causation of this industrial disease. If other countries imposed similar statutory obligations, they would obtain similar precious information; but at present only the English statistics, and, up to a limited extent, the French, are of remarkable value because (especially for the English cases) reports by independent inspectors and certifying surgeons are available.

In Prussia (1929), 1,124 cases of lead poisoning notified by certifying surgeons were distributed as follows: foundries and lead factories, 304; zinc foundries, 22; type-founding establishments, 6; printing works, 51; welding and tinning, 41; other processes connected with metallic lead, 25; storage batteries, 12; lead colour factories, 53; painting (building and other industries), 164; pottery and manufacture of lithograph transfers, 99; breaking up of ships, 6. In Bavaria (1927-1929), 617 cases of lead poisoning notified were distributed as follows: foundries and lead factories, 64; printing works, 77; welding and tinning, 37; storage batteries, 14; lead colour factories, 31; painting in the building trade, 84; enamelling, 147; pottery, 14; manufacture of lithographs and decoration, 12; various, 41.

United States.—In the State of Illinois, from 1 July 1914 to 30 June 1915, of 211 cases of lead poisoning, 50 were lead poisoning (156 among lead smelt and refiners); from 1 July 1920 to
1 July 1923, 318 cases of lead poisoning, 18 of which occurred in the painting industry; 52 in foundries, 199 in white lead, lead colour, and lead paint factories, 61 in lead foundries, etc. According to Wade Wright (1917), while, during the five years' working of the Massachusetts General Hospital, only 147 cases of lead poisoning were diagnosed, no less than 148 were diagnosed in the first year after an industrial clinic was opened in the same hospital. Of these 148, 68 were painters, 9 ship painters, 11 rubber workers, etc. In 1921 96 cases of lead poisoning, 45 affecting painters, 9 ship painters, 9 rubber workers, and 34 workers in the rubber industry, were reported to the Factory Inspection Department. In the State of New Jersey in 1917 54 cases of lead poisoning (out of a total of 83 cases of industrial diseases) were reported. In the State of New York during the period 1912-1922, of 744 cases of lead poisoning, with 104 deaths, 284 (53 deaths) were house or ship painters, 50 (8 deaths) coach painters, 152 (3 deaths) workers in accumulator factories, 64 (5 deaths) while lead and paint and colour workers (6 deaths), lead foundry workers, and 34 (25 deaths) workers in other lead industries. In the State of Ohio, the Workmen's Compensation Act of 1919 on occupational diseases notified in virtue of the Act of 1919 on occupational diseases numbered 8,628, of which 1,362 (18.9 per cent.) occurred in smelting metallic lead; 3,099 (35.9 per cent.) in enamel and repair of accumulators; 648 (7.5 per cent.) in white lead and minium factories, etc.; 391 (4.5 per cent.) in various branches of the painting trade; 177 in glassworks and potteries; 171 in the chemical industry, 247 in the printing trades; and 130 in various industries and occupations. Continuing attention to the last three years (1926-1928), which show 4,070 cases of lead poisoning, it is found that the figure for simple colic is 2,766; for incapacity for work lasting eight to thirty days, 3,069; whilst cases of permanent partial or total incapacity notified by the certifying physicians only reached the number of 13. Cases of death give a total of 9. Cases notified in 1929 amounted to 1,846, and in 1930, 1,682.

Great Britain.— Without going into details, which are given for the different industries in which there is risk of lead poisoning, the average number of cases in groups of years may be given as follows:

<table>
<thead>
<tr>
<th>Disease and industries</th>
<th>1912—1914</th>
<th>1915</th>
<th>1916</th>
<th>1917</th>
<th>1918</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
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<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
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<tbody>
<tr>
<td>Lead poisoning</td>
<td>522</td>
<td>245</td>
<td>302</td>
<td>361</td>
<td>412</td>
<td>324</td>
<td>375</td>
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<td>324</td>
<td>375</td>
<td>306</td>
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<tr>
<td>1. Smelting of metals</td>
<td>204</td>
<td>97</td>
<td>197</td>
<td>281</td>
<td>291</td>
<td>211</td>
<td>261</td>
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<td>2. Plumbing and soldering</td>
<td>31</td>
<td>13</td>
<td>17</td>
<td>23</td>
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<td>3. Shipbreaking</td>
<td>17</td>
<td>17</td>
<td>38</td>
<td>31</td>
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<td>5. Tinning</td>
<td>41</td>
<td>12</td>
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<td>6. Other contact with molten lead</td>
<td>291</td>
<td>15</td>
<td>151</td>
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<td>7. Lead red lead</td>
<td>321</td>
<td>27</td>
<td>201</td>
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<td>9. Vitrines enamelling</td>
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<td>11. Paints and colours</td>
<td>21</td>
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<td>12. Indiarubber</td>
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<td>13. Coachbuilding</td>
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<td>14. Shipbuilding</td>
<td>32</td>
<td>19</td>
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<td>15. Others treated by doctors</td>
<td>4</td>
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<tr>
<td>16. Other industries</td>
<td>73</td>
<td>19</td>
<td>19</td>
<td>19</td>
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<td>17. Painting of buildings</td>
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</table>

* The small figures are the number of fatal cases.
† From 1924 onwards the statistics include cases occurring amongst workers engaged on painting of buildings. Notification of these cases has been compulsory since 1 January 1927.
‡ Of which 131 occurred during demolition of battleships. These cases reached 30 in 1923, 17 in 1922, 7 in 1921 and 3 in 1920. They were made the subject of a special Memorandum published in April 1925 by the Factory Department of the Home Office.

A comparative indication of the incidence rate of lead poisoning among workers handling lead is given in the table below, and especially for the period 1910-1914, reveals interesting facts. Thus there has been a diminution in the number and severity of chronic cases, in the frequency of relapses, etc. Gastric symptoms are by far the most numerous, followed by anaemia, paralysis, rheumatic pains, headache, and encephalopathy. English experience has shown that paralysis and encephalopathy have been much less frequent in the period 1910-1914; paralysis is much more frequent among men than women, whereas it is the reverse in the case of cerebral symptoms.
LEAD POISONING

COMPARISON OF RATES OF INCIDENCE OF LEAD POISONING AMONG "LEAD" WORKERS IN CERTAIN LEAD INDUSTRIES

<table>
<thead>
<tr>
<th>Industry</th>
<th>Approximate number of persons employed in lead processes</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1911</td>
<td>1912</td>
</tr>
<tr>
<td>White lead</td>
<td>1,405</td>
<td>1,382</td>
</tr>
<tr>
<td>Electric accumulators</td>
<td>1,140</td>
<td>1,124</td>
</tr>
<tr>
<td>Pottery</td>
<td>5,710</td>
<td>5,447</td>
</tr>
<tr>
<td>Smelting of metals</td>
<td>2,820</td>
<td>2,451</td>
</tr>
<tr>
<td>Printing</td>
<td>38,300</td>
<td>38,800</td>
</tr>
<tr>
<td>Coach painting</td>
<td>29,306</td>
<td>28,288</td>
</tr>
<tr>
<td>House painting</td>
<td>150,000</td>
<td>150,000</td>
</tr>
</tbody>
</table>

1 The rates for house painting in this table are calculated in two ways, viz.:
(a) from the number of notifications and of death certificates received in the year. This, however, does not represent the total incidence, since notification is not obligatory in the case of house painters.
(b) on the assumption that in house painters the "deaths from lead poisoning" bear the same relation to the "cases of lead poisoning" as the corresponding totals do in the lead workers in the combined factory industries. This relation is known for the lead workers in the combined factory industries, and the "deaths from lead poisoning" among house painters are known from the copies of the death certificates received from the district registrars.

The cases of paralysis occurring in the period 1910-1914 numbered 606, of which 352 were definite paralysis and 253 of weakness or loss of power, affecting mainly the two forearms (352 paralysis and 181 weakness), 72 the right forearm (55 paralysis and 20 weakness), 50 the arms and legs (20 paralysis and 30 weakness), 35 the left arm (19 paralysis and 16 weakness), 29 the legs (9 paralysis and 20 weakness), 23 the fingers, etc.

The diminution in central nervous symptoms is notable. Thus in the period 1910-1914, 97 cases of epilepsy, psychical disturbance and optic neuritis occurred as compared with 60 during 1910-1914, and only 17 in the third period.

Examination of 247 death certificates in which lead poisoning was entered as directly or indirectly the cause showed that cerebral haemorrhage, paralysis and chronic lead poisoning accounted either alone or in combination for at least 195, that is, 78.9 per cent., while encephalopathy was responsible for only 8, or 3.2 per cent.

The English report, however, lays stress on the fact that "reported cases of lead poisoning in common with other forms of industrial disease do not represent quite all the incidence: latent, unrecognised and neglected cases undoubtedly exist as with other notifiable diseases."}

Netherlands. — Statistics for cases of lead poisoning are as follows:

<table>
<thead>
<tr>
<th>Industries</th>
<th>1912-14</th>
<th>1916-19</th>
<th>1920-23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painting</td>
<td>63</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>White lead works</td>
<td>97</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Printing works</td>
<td>22</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Enamelling works</td>
<td>7</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Pottery works</td>
<td>7</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lead rolling mills</td>
<td>8</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Lead factories</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Dockyards</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Various trades</td>
<td>18</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Total number of cases</td>
<td>219</td>
<td>42</td>
<td>58</td>
</tr>
</tbody>
</table>

SYMPTOMS

Like every other disease, the symptoms at the onset of lead poisoning are variable, and at this early stage there exists no symptom enabling a certain diagnosis to be made. Yet clinical appearances, combined with laboratory practice, make possible the diagnosis of the majority of doubtful cases.

The symptoms of acute and sub-acute poisoning are much the same: salivation, metallic taste in the mouth, and a feeling of retrosternal and epigastric burning when the salts have been introduced by way of the digestive tract. Further, there is severe colic, a subicteric facies, constipation, and sometimes vomiting.

The pulse is slow, though not always, and hard, the affected person is subject to convulsive attacks with a condition of stupor, shivering, etc. Occasionally these end fatally. Relapses occur after recovery and without fresh absorption of the poison.

The symptoms of chronic lead poisoning may be classed in two main groups: those of slight and those of severe plumism.

The symptoms of slight plumism may also be regarded as the premonitory signs of lead absorption; they mainly consist of presence of lead in the urine — sometimes intermittent — and existence of the blue line on the gums, Burton line.

Usually there are both general and special symptoms affecting particularly certain organs or systems which react to the poison according to the individuality of the sufferer (changes in the blood, especially in women, or a blue
line, or weakness of the extensors, etc.): whence comes the variety of the initial symptoms and the disagreement which at first sight would appear to exist between different writers on this point.

The general state of health is affected at a sufficiently early stage; the pallor to be observed is the sign of a generally bad condition. The saturnine facies is difficult to diagnose at first, and is much discussed. The patient complains of a peculiar metallic sweet taste, of loss of appetite; sometimes there is nausea and vomiting. Often there is fetid breath following on the bad state of the mouth and gums. According to Koelsch, with ordinary dental care the gums are normal though anaemic. When dental care is defective, and especially if there is individual predisposition, a more or less marked stomatitis exists, which is but an aggravation of the gingivitis coupled with dental caries and local nutritional defects due to the albuminates of lead circulating in the blood, so much so that it is possible to speak, as Koelsch does, of saturnine gingivitis or stomatitis capable of assuming a very severe ulcerative form.

A blue line is also frequently found at this stage. Distinction, however, must always be made between a blue line due to the deposition of lead dust on the buccal mucous membrane and especially on the gums, and the blue line attributable to elimination of the poison, which latter alone is evidence of lead in the system.

In Biondi’s opinion the first has no resemblance to the second, which is localised exclusively at the edge of the incisor and canine teeth, and falls where the teeth are absent. If the junction of the teeth and gums is touched with a solution of sodium monosulphide a line that is absent or faint is often brought out.

In cases of lead absorption the blue line occurs in some 20 to 40 per cent. (according to the amount of dental care bestowed) and in persons suffering from lead poisoning in 70 per cent. of the cases. Oliver has found it without other symptoms in 50 per cent. of lead workers; Koelsch in 12 per cent. of 5,000 working painters whom he examined. The blue line may however be lacking in 20 per cent. of cases of lead poisoning (Teleky) or even 25 per cent. (Oliver). According to Teleky, it should be regarded as the least frequent symptom of lead poisoning.

Bluish black specks are also found on the lips and inside the cheeks.

A late symptom sometimes noted is inflammation of the salivary glands—especially the parotid, more rarely the sublingual—on one or both sides, commencing insidiously with pain or swelling of the temporal or mandibular articulation, and involving disturbance in salivary secretion (increase or diminution). Parotitis due to lead was observed by Thielemann in 12 of 50 cases of poisoning (that is, 24 per cent.).

English writers describe further a special form of anaemia with prominence and a glintient condition in the cornea and sclerotic, suggesting organic disease of the heart which, however, may not be present.

The patient suffers from constipation, diminished flow of urine, in which, at an early stage, the presence of lead and haematoporphyrin is found.

Digestive disturbance is considered by some authorities as an early sign and admitted by all as of very frequent occurrence. The liver plays a considerable part in the morbid picture (cirrhosis, chronic angiocholitis, etc.), and finally changes in metabolism showing themselves in increase of uric acid in the blood and favouring attacks of gout in persons predisposed to it. Gout is said to be frequent in France and Great Britain, but is on the contrary rare in Germany. Severe anaemia, arteriosclerosis, nephritis, etc., find a sufficient explanation in the view taken that lead favours a uricemic state by retention.

Colic, which may sometimes be an early sign, is an epiphenomenon in chronic poisoning. Compared with other lead symptoms, it is without doubt the most frequent and, in view of the length of time it lasts and the frequency with which it occurs, represents a serious economical loss to industry. It is the expression either of the direct action of lead on the smooth muscle fibres of the intestine, or of indirect action on the mesenteric nerve supply.

The peripheral nervous system is affected by varied disturbances:

(a) Motor: in the classical type of paralysis of the forearm, partial or complete, uni- or bi-lateral, occurring either suddenly or slowly and insidiously. The paralysis is due to a lesion of the nerves and muscles in the region of the radial nerve (with the exception of the supinator longus), supplied by the musculo-spiral nerves, brought on rather as an effect of fatigue of the muscles involved than as an effect of local action of the poison through the skin. This hypothesis explains the greater frequency of the
paralysis in right-handed persons and of the left in left-handed. The hand drops, the middle and ring fingers are half flexed while the index and thumb are raised. The wrist drop may be complete and may reappear even after all contact with lead has been given up. The paralysis may also be generalised accompanied by functional disturbance of the muscles, developing slowly and affecting different areas in successive stages; generally only the trunk muscles escape.

Loss of power, localised in the extensors of the hand noted by Gilibert in 1906 is rarely an early symptom. Teleky, however (1923), regards this symptom as fairly frequently of early occurrence. Among 711 persons handling lead without obvious distress, the symptom was present in 17.4 per cent.; among 27 cases examined it was present in 52 per cent.; among 271 persons not in contact with lead in 1.85 per cent. only. This question has been studied by many experts. Kojran-ski (1928) has investigated this symptom in the aid of an apparatus contrived for the purpose, in the case of 316 lead workers and 192 workers not exposed to the lead risk. Amongst the latter, the force of extension of the hand exceeded by 72 per cent. that of the left hand whilst in the case of the lead workers this percentage dropped to 48.7. Other experts, however (Hertg, Vighortschik, Gelman, etc.), have not been able to arrive at positive conclusions. Levy and Weiss (1928) have used as a means of control the chronaxie, and it is certain that new methods of research will shortly permit of exact determination of this weakness of the extensor muscles. An important early or late sign is headache, even without the presence of albumen in the urine or retinal changes.

Muscular atrophy is the sequel of the paralysis (Letulle) and occurs in proportion to the degree of the latter. It is accompanied by discoloration (cyanotic); trophic changes, etc.

(b) Sensory (myalgias, arthralgias).

(c) The special senses (amaurosis or blindness which is always accompanied by encephalopathic symptoms: headache, vertigo, optic neuritis, albuminuric retinitis, hallucinations of sight and hearing, delirium, aphasia, etc.).

A complex series of symptoms — known under the name of "encephalopathy" — set up by lead in the central nervous system, comprises epileptiform convulsions, trembling, delirium, coma, amaurosis, blindness, and collapse.

This form, reported fairly frequently in Great Britain, has been less frequently noted in France, Italy and Germany, although cases affecting the brain have been described after two or three months only of contact with lead. Convulsions are most likely to affect young women workers soon after their first exposure to large doses of lead salts.

The cerebral attacks have been classed under three classical types (Grisolle): delirious, comatose and convulsive. Tanquerel des Planches was the first to distinguish them under the name of "lead encephalopathy", being accompanied by almost particular cerebral phenomena: convulsive crises, isolated or in series, almost always with fatal issue, sometimes supervening after a period of coma and at times affecting the victims of lead poisoning from the commencement of absorption.

Certain authorities regard them as a toxic meningo-encephalitis, while others are inclined to pronounce them hypertensive paroxysmal strokes.

Levy and Weiss (1928), who recently took up the study of this morbid manifestation, incline to the latter view, basing their judgment on the fact that lead acts as a poison by inducing anaemia and acting as a hypertensive agent and poisoning the nervous system, especially the periphery.

Hypertensive attacks of eclampsia as noted amongst victims of lead poisoning are to be distinguished from exceptional attacks of eclampsia, etc., affecting invalids. The term "encephalopathy", according to certain authorities, is restricted to this hypertensive crisis, usually of fatal termination, phenomenon of a hypertensive cerebral vaso-constriction. They suggest grouping the injuries resulting from these crises, such as deafness, amaurosis and transitory aphasia, under the heading "slight encephalopathy" and retaining for lead eclampsia the term "severe encephalopathy". The first group often constitutes the premonitory symptoms of the fatal attack of eclampsia.

In 1929, Niederland, of Aquisgrain, had an opportunity of reporting 11 cases of encephalopathy amongst victims of chronic lead-poisoning; 3 of the cases were typical lead encephalopathy; in 2 the encephalopathy was of the Jakssonian type; there was 1 case of chronic lead encephalopathy and 2 of a slight form with rapid evolution; another 2 of a type with retarded evolution and lastly 1 chronic nephritis with uraemia and possible previous encephalopathy.
The respiratory system is also affected, presenting various forms always terminating in sclerosis. Probably supervening on this, in certain individuals tubercle develops as a result of the special conditions of environment and life of such individuals. As a matter of fact, writers agree that tuberculosis does very frequently attack persons suffering from plumblism, and in any case that lead absorption predisposes to it. Asthma is also of fairly frequent occurrence.

Changes in the blood vessels, high tension pulse, arteriosclerosis, etc., which in the opinion of some authorities are early symptoms of lead poisoning (on this point opinion varies greatly), are considered by the majority as late symptoms of chronic lead poisoning.

Nevertheless, James Lasius (1930), who engaged in research into hyper- tension in lead poisoning, considers that, apart from cases of nephritis, there can be no question of increased pressure amongst workers who have absorbed small quantities of lead, even over a period of thirty to forty years.

The elimination of lead by the kidneys is not unattended with danger to that organ so important to the animal economy, and its injurious action upon the secreting epithelium is to be detected early in the stage of poisoning. Later the damage extends to the connective tissue and to the vessels so that the slow and almost continuous changes pass on relentlessly to the condition of chronic interstitial nephritis — the small atrophic kidney.

According to some German and Dutch writers, presence of haematoporphyrin in the urine is said to be an important sign of lead poisoning — at least when in excess of a certain minimum quantity. The porphyrin is thought to be formed in the intestine starting with haemoglobin and helped by the action of aerobic and anaerobic bacteria.

It is hardly necessary to insist on the harm done to the organs and functions of generation both of man and woman as they are now well known and admitted. Of the endocrine glands the suprarenal capsules resent most the action of lead. In consequence the important endocrine functions are disturbed and the effect of this upon the clinical picture presented by the patient can readily be imagined.

The organs of sense do not escape the disastrous action of lead. Five cases of ocular injuries due to lead were noted by Pedley (1930), who found them amongst 100 cases of lead poisoning studied in the course of the four previous years. The injuries consisted in optic atrophy (2), neuroretinitis (1), probable retrobulbar neuritis (1), sub-hyaloidian haemorrhage (1). Whilst lead might be considered as the probable etiological agent, it cannot, however, be recognised as the certain cause in these cases, in the absence of direct proof.

These various clinical symptoms are not in themselves characteristic, with the exception of colic, and their presence can only be determined by reference to the history of the case and the presence of lead in the urine. For reasons still unknown, individual predisposition favours in different individuals occurrence now of this, now of that clinical picture, and while colic, nephritis and the mental symptoms may appear, even after a short exposure to the action of lead, the changes in the vessels and kidneys are always an indication of late and terminal effects. Even colic is at times the expression of an episodic absorption of a larger quantity of the poison, and at times of a peculiar reaction of the subject to the action of lead.

Blood.— Among the alterations of the blood, diminution of the haemoglobin, of the number of the red blood corpuscles, and inversion of the leucocytic count are certainly, from the point of view of early diagnosis of plumblism, of less importance than certain changes in the red blood cells themselves.

Diminution of the haemoglobin in severe cases may be remarkable (40-50 per cent.), the number of red cells may fall to 3½ millions or even to 2,800,000. The picture of pernicious anaemia, however, is never seen.

Further, lessened plasticity of the red cells, polychromatophilia, punctate basophilia, the bodies of Jolly and Cabot in the red cells, are cited as early symptoms. Polychromatophilia and punctate basophilia are now recognised as an indication of disturbed regeneration, if not of an embryonic or pathological reaction of the blood-forming tissues, which direct into the circulation a more or less large quantity of immature red cells, or, at any rate, of cells with embryonic characteristics, rather than the result of a degeneration of these cells following on action of the poisons, as was the view previously held.

The frequent presence of punctate basophilia in the blood, in the absence of other symptoms, should be regarded as a note of warning and evidence of latent poisoning. The value of this
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indication is sufficient to confirm diagnosis based on other symptoms (see article "Blood: Changes due to Occupation").

Punctate basophilia considered characteristic by Schnitter, Grawitz, Schmidt, Hamel, Moritz, Embden, Schoenfeld, Sellers, etc., is held, on the other hand, by other authorities as not characteristic because it is observed in other diseases and forms of poisoning and even occasionally in the blood of healthy persons. Further, it is said to be absent in 50 per cent. of cases of plumism (Linenthal) or even 80 per cent. (Harris). Others mention smaller percentages: 25 per cent (Teleky), 27 per cent. (J. Russel); and 17 per cent. (Lutolawsky). But though, according to Nægeli, punctate basophilia is found in healthy persons, the number is very small, while in persons suffering from lead poisoning they represent a fairly frequent change and are sometimes present unaccompanied by anaemia.

While admitting the value of the presence of punctate basophilia in the early stage of lead poisoning, Thomas Oliver is not however willing to ascribe to it the great value placed on it by certain authorities as a guide to diagnosis. In certain cases presenting very clearly-marked symptoms of lead poisoning punctate basophilia was absent, and the same was found to be the case amongst animals fed on lead for several weeks.

A comparative study made by Trautmann (1908) brought to light the fact that while punctate basophil red cells were found in 14 per cent. of anaemic subjects examined and in 21 per cent. of healthy persons, they were found in 56.2 per cent. of lead workers undergoing periodic medical examination, and in 70 per cent. of painters examined. Taking as a minimum standard for punctate basophil red blood cells 100 per million, he showed that only 2 out of 10 anaemic subjects (1 only if 200 per million were adopted as minimum standard); and 2 of the 100 healthy persons (not 1 if 200 were the minimum standard) gave this blood reaction, while it was positive in 20.6 per cent. of the lead workers (11.2 per cent. with a 200 standard), and in 33.3 per cent. of painters (21.7 with a 200 standard).

Very interesting observations have recently (1925) been made by W. Blair, W. R. Williams and L. Cunningham on the toxic action of lead administered intravenously for the treatment of cancer. The intravenous administration of lead gave rise to punctate basophilia some hours after the first dose of lead was given. Anaemia and polychromasia (also very frequent), anisocytosis and poikilocytosis were of later development. The authors do not share the opinion that punctate basophilia of the red cells occurs in normal blood. Of 117 patients 76 showed punctate basophilia, 24 punctate basophilia accompanied by nucleated red corpuscles, 3 others showed other pathological changes. The remaining 14 cases only showed polychromasia. As regards the white cells, the authors report that leucocytosis is common while leucopenia is rare, but there is nothing specific or definite in regard to these changes observed in the white cells.

The blue line is of uncommon occurrence when lead is administered intravenously. On the other hand, colic is of frequent occurrence, especially after heavy doses. Psychopathies are rare,
but the retina and the kidney are often affected. The action of lead on the latter is so frequent and so intense as to require the greatest precaution in administration of the drug.

But though the value of this line of enquiry has become somewhat less apparent from a medico-legal point of view, seeing that the number of punctate red cells does not run parallel with the severity of the poisoning, and though the red cells affected with polychromasia are more numerous than those with punctate basophilia, it must be remembered that these pathological forms appear where there has been quick absorption of large quantities of lead, or when already much lead has been absorbed into the organism and begun to act. They indicate the imminence of lead poisoning, especially in particularly sensitive individuals, and, from this point of view, their presence has a practical importance of even greater value in that it enables us to suspend or transfer to other work the persons running the greatest risk.

Though, according to Teleky, an increase in the punctate basophil red cells is a rather capricious sign, their presence is found almost without exception in cases which have later developed grave symptoms.

In regard to the leucocytes, even in mild cases there is a tendency to a leucocytosis, although slight, and in the more severe cases of anaemia a rather marked neutrophil leucocytosis; a mononuclear leucocytosis with morphological changes in the white blood cells has been observed by Biondi, Legge, Goadby, Seitz (1923, amongst composers), and Thiele (1921, among painters), even in the absence of punctate basophil red cells.

**Technique**

**Vital staining.** — To bring out the presence of punctate basophilia in the red cells, a small quantity of a 10 per cent. solution in absolute alcohol of brilliant cresyl blue (or other azidine stain) is spread out by means of a glass rod on a slide previously slightly warmed. The alcohol evaporates immediately and the slide remains faintly stained blue (only visible when looked at against a white background). A drop of blood received on a coverslip is then placed on the slide without exerting any pressure, so that the drop spreads slowly and gradually gives rise to little bluish arborisations at the periphery. On examining (with the oil immersion) the central portion of the preparation, the filamentous substance of the red cells is seen to be coloured blue and the granular red.

**Dry staining.** — After securing a good smear on a slide (without having the red cells in rouleaus or superimposed one on another) and after drying the smear, it is stained with two or three drops of a solution of May-Grunwald for about 3 minutes. A few drops of water are then added to dilute the solution (in the proportion of 1 to 2) and it is allowed to act for 2 minutes. Then without washing, the slide is passed into diluted Giemsa solution (1 drop in 1 cub. cm. of distilled water) for 5-10 minutes. The slide is then washed under running water and dried with blotting paper (Biondi). The polychromatic red cells and the basophil granules come out blue, the azurophil granulations, Jolly bodies and Cabot rings in violet red. At the same time, if desired, the mononuclear leucocytosis can be demonstrated. Gilbert fixes the smear in absolute alcohol, stains for two minutes with an alkaline solution
of methylene blue (2 grm. of blue, 12 grm. of bicarbonate of soda in 200 grm. of distilled water) and washes until the colour disappears.

Schnitter (1919) uses Manson's methylene blue; Godby (1912) uses Romanowski's stain as modified by Wright; Hayhurst uses Harlow's solution which is the method used by the Division of Industrial Hygiene of the Provincial Health Office of Ontario. This method is really only a double stain with the one liquid (eosine and methylene blue), which also serves to fix the preparation as the colours are dissolved in methyl-alcohol.

In 1922, Schwartz proposed the method of the dense drop and staining by methylene blue and Manson's borax. But the presence of basophil red corpuscles obtained by this method must be interpreted very critically to avoid inexact conclusions. Koch (1924) used a solution of Giemsa Blue II of 0.05 per cent. strength (for two minutes).

The view, however, expressed by Lehmann is endorsed, viz., that it is far better to make several examinations than to pay too much attention to a minute count; also that of Teleky that the same method should be persisted in throughout an enquiry so as to avoid different results. Thus, for example, he has shown that in 20 cases of lead poisoning clinically established the number of red cells showing punctate basophilia varied from 38.6 to 100 according to the method adopted.

DIAGNOSIS

As in all diseases, the physician will not base the diagnosis of lead poisoning on one symptom alone, but once the action of lead or its compounds is suspected, he will diligently seek all the effects on the organism which the poison is capable of inducing. The characteristic signs are mainly: the blue line on the gums, colic, loss of power or paralysis of the muscles. The necessary steps to confirm the presence or absence of lead are examination of the urine or blood.

Though, as is the view of several writers, the blue line on the gums is the sign most constantly present (in 90 per cent. of cases according to Marvin Shie, 1921), it may certainly be lacking in undoubted cases of lead poisoning, especially when the persons exposed have bestowed careful attention to dental hygiene. The line is frequently preceded by a red line with a violet tinge. Other authorities consider that the line is present in only a third of the cases.

If it is not very marked it can be brought out by touching the gums with a 5-10 per cent. solution of monosulphide of sodium; oxygenated water, on the other hand, bleaches it. It has to be distinguished from other staining round the gums by such toxic substances as bismuth, zinc, copper, silver, mercury, etc., more especially as lead may be present without its presence being expected. Thus Koelsch describes the case of a brassworker who showed a deep blue line which, although apparently due to copper, was in reality due to lead as the dust showed 10 per cent. on analysis.

Whatever view is held, the blue line shows that the worker and his companions are exposed to the action of lead dust and that lead poisoning is imminent if they continue to work under the same conditions.

Colic is usually associated with constipation (more rarely diarrhoea) and is characterised by intermittent attacks, by its situation (the lower part of the belly), by slowing of the pulse, and by the relief given on pressure over the abdomen.

Loss of power, or paresis, localised most frequently in the hands (wrist and fingers), may also be an early sign of early poisoning in some persons.

The absolute value of the finding of punctate basophilia in the diagnosis of lead poisoning, as it was originally viewed by Grawitz, has had doubt cast upon it by other authorities. Its presence, however, has always the value of a note of warning which is not denied by those who will not go as far as Grawitz, e.g. Naegeli, who says: "The presence of punctate basophilia has a quite special value in the diagnosis of lead poisoning". The search for it must be carried out on very strict lines (see above); authorities are however not in agreement as to the necessity of basing diagnosis on a minimum number of basophil cells. Among those who hold this view, Schnitter would consider it advisable to transfer to other work every person employed showing more than 100 per million and considers as suffering from lead poisoning everyone with more than 500 per million. Schoenfeld bases a positive diagnosis on a count of 100 per million; Schmidt considers as suspicious every case showing this number, but would not suspend under 500. This proportion has been accepted in Germany. Though, as some writers say, it is wise to accept the view that 100 to 300 basophil red cells per million is an indication of latent lead absorption and 500 of active poisoning, others
are of opinion that this method is too much under the influence of subjective factors.

Kretschner (1924) considers that the presence of punctate basophilia is proof of serious poisoning when this is not accompanied by other symptoms, and Koch (1924) proposes to regard the total number of basophil red cells and polychromatophil red cells (which he calls granulo-polychromasia) as an indication of the gravity of poisoning. He fixes 100 granulo-chromatic red cells per million as the minimum limit for denoting suspicion and 500 per million for denoting cases of recognised lead poisoning.

In the course of a long enquiry in German lead colour factories, Lehmann recommends for consideration as signs of poisoning: punctate basophilia (250 and over per million), the blue line, haemoglobin (below 80 on the Talquist scale), high arterial pressure (above 100/50 for the age and sex of the individual), presence of albumin in the urine (even a trace), weakness of the extensors of the wrist. The presence, of only one of these signs is in Lehmann's opinion sufficient ground for looking upon the individual as "normal". Presence of 2 as slightly suspicious, of 3 to 5 as slightly affected, In the first group figures principally punctate basophilia and less frequently the blue line and anaemia; in the second group punctate basophilia and the blue line followed by punctate basophilia and diminution of haemoglobin. In the third group punctate basophilia (89 per cent.) and the combination of punctate basophilia, blue line and diminution in the haemoglobin (75 per cent.).

Opinion is very divided as to the practical value as a test of the resistance of the red blood corpuscles (Liebermann test) utilising saline hypotonic solutions.

Examination of the blood must be carried out by experts, and when this is the case it is of valuable assistance and cannot be dispensed with today, especially in doubtful cases. It is of the greatest assistance in deciding whether or not the suspension of a worker is necessary and urgent.

Questions of diagnosis are of special importance from the medico-legal point of view. If the symptoms which are really characteristic of lead poisoning (blue line, colic, paresis of the muscles supplied by the musculo-spiral nerve with the exception of the supinator longus) are not accompanied by proof of lead in the urine (even when assisted in its elimination by the administration of iodine) a definite diagnosis of lead poisoning could not be made. This position is still very important in the presence of other morbid symptoms attributable to lead but less characteristic, such as arthralgia, small atrophic kidney, etc. Such lesions, indeed, could not be proved to be due to lead, even if lead had been found in the urine. Moreover, punctate basophilia, and finally presence in the red blood cells of the Jolly bodies and Cabot's rings, although not characteristic of this form of poisoning, may, however, help in confirming the diagnosis.

In conclusion, it may be said that, though absorption of lead by the individual can be proved (by finding lead in the urine, and even in the blood serum by presence of a blue line, etc.), it is not possible, from the medico-legal point of view, without such investigation to assert absolutely, with the exception perhaps of cases of colic, that a given syndrome is saturnine in origin. It is not at present possible in a particular case to assert of certain symptoms that they are known to be the sequelae of chronic lead poisoning (arteriosclerosis, small kidney, etc.), that lead is the cause, and that it is the sole cause, even though it can be proved that there has been exposure to lead absorption.

**DEMONSTRATION OF LEAD**

(a) In the air, see article "Lead".

(b) In the organism (liquids, tissues, etc.).

— Every enquiry as to the presence of lead must always be preceded by a control test of the capsules, filter paper, reagents, etc., in order to be sure that there are no traces of lead in them. Capsules of aluminium can usefully be used, rather than those of porcelain, which may sometimes yield some lead.

Organic matter must especially be destroyed (by the method of Fresenius and Babo, etc.). In the case of urine, for example, the following procedure may be adopted: 150-200 grm. of urine (of the 24 hours' collection) are acidified slightly with nitric acid and concentrated over a bath marie and then completely decomposed directly over a fire. The dry residue is then treated with pure ammonium nitrate and the calcined product taken up in warm distilled water, slightly acidified with nitric acid, and submitted to the action of a solution of hydrogen sulphide or of a current of hydrogen sulphide gas. If lead is present a black precipitate is deposited. To control the reaction, collect the precipitate and dissolve it in nitric acid, dry a portion, take it up with distilled water, and colour it with a solution of sodium iodide: a yellow colour, more or less intense, is obtained, due to
the formation of lead iodide; treat another portion with a decinormal solution of potassium bichromate when a yellow precipitate of lead chromate is obtained; treat a third portion with two or three drops of sulphuric acid, evaporate until no more white fumes are given off; after cooling and dilution with distilled water a white powder of sulphate of lead is obtained.

Numerous other methods of procedure have been proposed to demonstrate the presence of lead as, for example, electrolytic methods and that with Trillat’s reaction (a tetramethyl base of diphenyl-methane dissolved in pure acetic acid) which reveals the presence of lead dioxide in a proportion of 1 in 3,000,000 and a concentration of less than one-hundredth of 1 mg.

Minot, Denis (1919) and Schumm (1922) have proposed modifications in the electrolytic method, but several experts are of the opinion that the chromate method suggested by Fairhall (1922) is the best, though it requires delicate manipulation and close attention. For research for lead in the urine, Fairhall has also proposed modifications in the method currently used.

Research for lead can also be made in the cerebro-spinal fluid (hexanitrite) method (Weller and Christensen, 1925); in the blood by the micro-chemical method proposed by Schmidt (1928-1929) with spectroscopic control. Walther and Werner Gerlach (1931) have recommended a method based on spectral analysis of emission for detecting lead present in small quantities in small fragments of tissue. Finally, there may be recalled the radio-chemical method of research for lead circulating in the system (Christensen, 1924).

HYGIENE.

On the technical side every effort must be made to stop lead dust and fumes by substituting mechanical methods for hand labour or by utilising automatic methods or wet processes according to the technical possibilities of each process. Every escape of dust and fumes must be prevented by locally-applied exhaust ventilation with hoods over each apparatus, and by effecting separation of dusty and dangerous operations in distinct workrooms, by provision of overalls, respirators, etc. so as to minimise as far as is possible the accumulation and absorption of toxic matter. Whatever possible lead should be replaced by substitutes either harmless or less injurious (e.g. in the pottery industry by the use of low solubility fritted glazes, in painting by the use of varnishes), and finding a substitute for metallic lead used as a weight or support in many jobs (e.g. in cloth-cutting or diamond-polishing, weights for Jacquard looms, etc.).

General measures against lead poison-
on industrial medicine, especially in Germany.

In considering the very serious problem of the transfer or suspension of a worker suffering from saturnism, the surgeon must take into account several conditions having a detrimental effect on health, such as former or recent attacks of lead poisoning, marked anaemia, tendency to hysteria and epilepsy, existence of extensive oral sepsis, mental weakness, careless personal habits, such as want of attention to cleanliness of hands and teeth or of clothing, or biting of nails, unwashed hands, etc., maladies which have induced poverty of the blood (e.g. malaria), short sightedness causing undue proximity to the work; amongst women menstrual troubles and especially pregnancy have to be borne in mind. On commencing work, therefore, every worker requires to be made the subject of careful individual examination and similarly any worker resuming employment after cessation for a time for illness, the object being to avoid taking up or resuming work with symptoms predisposing to lead poisoning. If necessary, the surgeon should consider transference to other work in the factory or to other employment free from risk of lead poisoning. Teleky (1924) advises change of occupation when the clinical picture of lead absorption shows itself rapidly even in the absence of the cardinal signs of plumbism. The association of granulo-basophilia with cachectic appearance should be a signal for transference to other work, according to the same authority. When granulo-basophilia only is present it might be advisable to wait and observe the evolution of the case.

When, however, the symptoms of poisoning appear rapidly among factory workers the management should be at once informed, because the conditions of work obviously require to be improved.

The periodical examination should be carried out so that the greater the risk the shorter the intervening period. Thus, for example, it should be weekly for workers dealing with lead compounds, white lead and lead colours, etc., monthly in accumulator works, smelting, painting, pottery, etc., quarterly in tinning (kitchen utensils, etc.) by means of vitrifiable coating substances, enamelling, etc. (see these articles).

LEGISLATION

Cases of lead-poisoning due to lead and its compounds are subject to compulsory notification in almost all the countries in which compensation is granted as for industrial accidents: Argentina, Australia (Queensland, South Australia, Victoria, Western Australia), Austria, Belgium, Bolivia, Brazil, Bulgaria, Canada (Alberta, British Columbia, Manitoba, North Branswick, Nova Scotia, Ontario), Chile, Cuba, Ecuador, Federated Malay Straits, Finland, France, Germany, Great Britain, Greece, Hungary, India, Ireland, Italy, Japan, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Portugal, South Africa, Sweden, Switzerland, U.S. S.R., United States (California, Connecticut, North Dakota, Illinois, Massachusetts, Minnesota, New York, New Jersey, Ohio, Porto Rico, Wisconsin, etc.), Venezuela, Yugoslavia.

For details see articles on the different lead industries and the article "Occupational Diseases: Definition and Compensation". For the Washington Convention, see articles "White Lead" and "Red Lead".

Numerous leaflets and instructions as to the medical examination of workers engaged in the lead industries have been published; those issued by the German Government are reproduced below.

Lead Notice

"Any person who in the course of his occupation comes into contact with lead or lead compounds (with the exception of galena) or substances containing lead is exposed to the danger of lead poisoning. This danger is the greater owing to the fact that the poison does not betray its presence to the worker either by smell or by taste (except in the case of acetate of lead) and thus he may take it into his system unawares.

"Lead poisoning is usually caused by lead, which is left sticking to the hands or clothes or beard, being taken into the mouth in very small quantities during eating, drinking, smoking, snuff-taking, or chewing tobacco or inhaled in the form of dust during work.

"The lead gradually accumulates in the body, and symptoms of lead poisoning appear sooner or later according to the quantity of the poison absorbed and the resistance of the worker.

"A blue-grey line on the gums (‘blue line’), close to the teeth, is a sign that lead has already been absorbed by the body in considerable quantities, and this disease due to lead poisoning is about to declare itself. The presence of a blue line should therefore cause the worker to take more care than before that he absorbs no further quantities of lead in the course of his work; it is at this stage possible that he may escape actual illness. On the other hand, it often happens that within a very short time, but sometimes not for some weeks or even months, lead poisoning specifically declares itself, and this is usually very painful, protracted, and in certain cases dangerous to life."
Prevention of Lead Poisoning

"Care and cleanliness are the surest protection against lead poisoning. In particular, the following directions should be observed:

(1) Hands and working clothes must during work be protected as far as practicable from contamination with lead, lead compounds, or substances containing lead. The nails must always be kept short. Smoking, snuff-taking, and chewing tobacco during work must be discontinued. Cigarettes, tobacco, pipes and other smoking utensils must not be brought into the workrooms.

(2) Workers must not take food and drink, or leave the workplace, till they have removed their working clothes and thoroughly washed their hands with soap and nail brush. The face, and especially the beard, must also be carefully cleansed if they have been soiled during work.

(3) The prescribed working clothes must be worn for all work in connection with lead. Respirators, damp sponges or bandages covering mouth and nose must be worn during all work involving the raising of dust, unless the dust is immediately and completely removed by exhaust ventilation, in order to prevent the inhalation of dust containing lead.

(4) The widespread belief that the regular use of certain remedies (iodide of potassium, sulphur tabloids, Glauber salts and other aperients), or milk drinking, is sufficient to prevent lead poisoning, is incorrect. On the other hand, a certain value must be attached to nourishing and fat-forming diets, and to that extent to milk drinking also. The use of alcoholic drinks, especially brandy, facilitates the attack of lead poisoning, and is therefore to be avoided.

(5) Exercise in the open air, gymnastics, baths, etc., increase the resisting power of the body, and should therefore be encouraged as much as possible.

If a worker who comes into contact with lead, lead compounds or substances containing lead becomes ill, he should immediately, in his own interest and that of his family, consult a doctor, and at the same time tell him that he has come into contact with lead during his work."

Instructions for the Medical Examination of Lead Workers (Dated 27 January 1920):

In pursuance of section 17 of the Order dated 27 January 1920 respecting the installation and working of establishments for the manufacture of lead colours and other lead compounds, the German Federal Minister of Labour issues the following service instructions for the medical examination and supervision of the health of workers in these establishments.

I. Examination prior to Engagement

The medical practitioner must examine every worker before he is engaged for work in any of the undertakings specified in section I, paragraph 1, of the Order respecting the installation and working of establishments for the manufacture of lead colours and other lead compounds, dated 27 January 1920, in order to ascertain whether his health is such as to render him suitable for employment in the establishment. The medical practitioner must, before the examination, ask the worker in what kind of undertaking he has worked hitherto, whether he has ever suffered from lead poisoning before, and what symptoms then appeared.

Workers must not be employed in the undertakings specified, except in cleaning the rest room, canteen, cloakroom, lavatory and bathroom, and in washing and mending working clothes; and male workers under 18 years of age must not be employed in establishments devoted mainly or exclusively to the manufacture of lead colours or other lead compounds (section 10 of the Order). The medical examination is consequently unnecessary for these workers.

The medical practitioner must regard as unfit for employment any person who has already suffered severely from lead poisoning (e.g. lead paralysis, serious or repeated attacks of lead colic), or who still shows symptoms of lead poisoning, however slight, or who owing to the nature of his previous employment must certainly have absorbed lead, and in whose case the present medical observations and the blood test—especially the presence of numerous basophil granules in the red cells—indicate that the appearance of lead poisoning in the near future is to be feared. Weakly or sullen persons must also be regarded as not suitable, especially those suffering from pulmonary tuberculosis, from diseases of the circulatory system or of a syphilitic nature, or those suffering from diseases of the kidneys, and persons addicted to drink.

The medical practitioner must, at the close of the examination, instruct the workers found suitable for employment as to the dangers of lead poisoning. His instructions must be based on the popularly phrased Lead Notice 1 issued by the Federal Minister of Labour. They must include due reference to the special circumstances of the works, namely, the way in which the worker must behave in order to guard against the absorption of lead, and to the symptoms of incipient lead poisoning.

The medical practitioner must, after the completion of the examination, prepare for the employer a written statement of his opinion as to the suitability of the persons examined for employment in the works.

1 Reproduced above.
II.—Periodical Examination of the Workers

The medical practitioner must inspect persons employed in the works at least twice a month in the establishments in which white lead, lead sulphate, litharge, or red lead is manufactured, and at least once a quarter in all other establishments to which the aforementioned Order applies; he must observe symptoms of illness, and especially those of any illness connected with lead, and examine thoroughly those cases which seem to him suspicious (section 17 of the Order).

During his inspections, the medical practitioner must ascertain by questioning each worker, whether there are any signs of injury to his health through lead work, or whether he is actually already suffering from lead poisoning. He must thoroughly examine persons whose cases appear to him suspicious in this connection, in a special room set apart for the purpose.

In the course of both the inspection and the examination, the following signs of illness especially must be watched for as symptoms of impending or already existing lead poisoning, viz.: the blue line, pallor, lead discoloration (pale, somewhat yellowish skin, bluish grey discoloration of the mucous membranes, pale yellow colour of the sclerotics), wasting, debility, pains in the head, loss of appetite, constipation and other digestive disorders, attacks of colic, diseases of the circulatory system (arteriosclerosis), arthralgia, disorders of the organs of sense, paralysis, albuminuria haematoporphyrinuria, kidney disease, increased blood pressure, reduction of the haemoglobin content, of the blood (anæmia), appearance of basophil granular erythrocytes (granular red cells) or other blood changes (polychromatophil erythrocytes, increased number of leucocytes together with numerous transitional and atypical forms), saturnine encephalopathy, cachexia.

The medical practitioner must carry out the special examinations for verification of the presence of lead poisoning in accordance with the appended directions.

If the examination establishes the presence of forms of lead poisoning which are dangerous to life or which may become so if long continued, especially saturnine encephalopathy, cachexia, chronic inflammation of the kidneys (not merely albuminuria), or recurrent paralysis, the medical practitioner must send to the employer a written proposal for the permanent exclusion from lead work of the person examined. He shall do the same in a case in which, although only slight lead poisoning is present, it has developed very soon after beginning lead work, or has recurred at short intervals and with increasing severity, and so indicates the presence of unusually high susceptibility to lead. Permanent exclusion from lead work must be proposed, moreover, in the case of those persons who are found to be suffering from pulmonary tuberculosis or alcoholism, even if they show no signs of the influence of lead, or are not suffering from lead poisoning:

In all other cases of lead poisoning, the medical practitioner must propose in writing to the employer the temporary exclusion from lead work of the persons concerned until the symptoms have disappeared.

If only granular erythrocytes (less than one granular cell in 50 fields of the microscope) are detected on examination — and if other diseases are not present, especially other disorders of the blood supply (such as malaria, pernicious anaæmia, leukaemia, cancerous cachexia, nitro-benzol poisoning) — or if a worker is found to have a blue line, lead discoloration, or haematoporphyrin in the urine, these symptoms must be regarded as signs of the effects of lead, but the patient should be regarded as not yet suffering from lead poisoning but rather as a lead carrier (Bleitragere). If it is feared, as a result of the medical observations and the blood test (especially numerous granules in the red cells), that a lead carrier will shortly develop lead poisoning, the medical practitioner must in his case also send to the employer a written proposal for his temporary exclusion from lead work until the symptoms have disappeared, and the condition of the blood has improved.

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getting nipped in the door and bruises are caused by the regulating cord. Muscular lesions are not infrequent.

All these injuries should receive immediate treatment so as to prevent possible septic complications or absence from work due to sequelae as far as possible. This is especially necessary after injury to the head and spinal cord, because, in the latter case, long illness may be involved, with slow convalescence, and sometimes, indeed, after-effects lasting for years.

Surgical injuries are frequent enough from thickening of the sheaths of the flexor tendons of the fingers as the result of pressure from the regulating cord; and flat-foot from long standing. Flat-foot will readily yield to early treatment (slippers and special shoes); but in some cases treatment takes longer (application of plaster bandages), or even calls for change of employment. Varicose veins are frequent, and in severe cases may ulcerate. Bandaging may ease the condition. Hernia is not more frequent than in other occupations, and when it occurs may have originated in some previous employment. Glands, pharyngitis, laryngitis, bronchitis, come from exposure to draughts, especially in the aged. Tuberculous subjects should not be employed in this occupation on hygienic grounds (spread of infection). Arteriosclerosis cannot be said to be related to the occupation. Still, when it is present it would appear to increase rapidly among busy liftmen. Nervous and gastric disorders are no more frequent than in other occupations, although young liftmen in busy places show signs of it. Young persons are often subjects of headache and fainting attacks necessitating temporary absence from work. Cases of gassing have been reported when gas has been the motive power for working the lift.

**Legislation**

Generally, fairly detailed measures are enacted for safety of lifts and hoists in coal mines, factories, and private houses. Periodical examination is desirable. As to the conditions of work for young persons, for example, the Netherlands Decree of 10 August 1930, section 8, subsections 5-6.

**Bibliography**

Lignite


Lignite is a kind of coal which, according to its derivation, may be classified between lianthrax and peat. It assumes very varied aspects: black and compact, with a brilliant surface like lianthrax; fibrous, with the form, structure, and sometimes the colour of wood, utilised as a pigment in painting (Cassel and Cologne umber), and sometimes polished and designated "jet" when friable, the "bituminous lignites" or "heavy lignites", which resemble petrol rock in character. They are utilised for their distillation products (paraffin, oils, spongy coke). (See article "Shale Oil Industry").

The occupational risk and the state of health of the workers handling lignite have been very little studied, and this neglect may reflect the inferior origin from the point of view of industrial value.

Lignite

![Diagram of Lignite products]

Tar (specific weight 0.830-0.890)

Lignites constitute the first stage of the combustibles of fossil origin. They are to be found in France, Italy, Ireland, Switzerland, Central Germany, Galicia, the United States, etc.

They are generally classified in three categories: the "fossil woods", recalling in aspect the original wood; the ordinary "lignites", of an earthy aspect containing very often a large quantity of pyrites, also of lignite as compared with other combustibles.

Lignite is found in deposits, in stratified layers, and in veins at very varying depths (attaining at times 200 to 300 metres); it is also met with at the surface in banks; in the latter case it is quarried in the open.

The lignite occurs in solid form, in irregular pieces, the colour of which varies...
from black-brown to blackish-yellow. Its vegetable structure may be seen with the aid of the microscope.

Lignites are used industrially for the production of motive power, electric power, and furnace heating; they are also used for domestic heating.

Lignites burn with a long fuliginous flame, but even once the flame is extinguished combustion continues, liberating dense smoke, soot and gaseous products of combustion, amongst others, sulphurous fumes, which at times are present in such great quantity that they destroy the furnace grating.

The cinders are in the form of fine dust of a colour ranging from grey to reddish brown according to their iron content. They contain chiefly compounds of silica, alumina, oxide of iron, of lime, of sulphuric acid, and small quantities of magnesium, potassium, and soda, etc.

Lignites do not melt, but may be distilled without agglomeration. The dry distillation of lignites produces gases which may be used in special furnaces, oils, water, and gas retorts of refractory material (chain offes), ground paraffin, in the carburation of lighting gas, and in dry cleaning.

Lignites contain more or less extensive quantities (up to 8 per cent.) of a kind of wax which, since the war, has been utilised in Europe for leather polishing, lubricating greases, insulating material for electric cables, gramophone discs, etc.

The distillation of lignite under reduced pressure or in a current of hydrogen is generally replaced by extraction by means of solvents (alcohol, benzine, toluene, acetone, xylois, pyridine, phenol, chloroform, carbon tetrachloride, etc.) The best quantitative results are obtained with benzene-alcohol or toluene-alcohol. The lignite remains, however, impregnated with the solvent, which is recovered by steam.

The crude wax has to be purified and relieved of its resinous content, easily effected by the separation processes proposed by technical experts.

In Germany, bituminous lignite is used in the paraffin industry which, when distilled, furnishes a lignite or bitumen tar containing decomposition products of bitumen in the form of oils and of paraffin. The unaltered bitumen is extracted by means of boiling benzol, and placed on the market under the name of "Montan" wax. The distillation of the ground lignite is effected in vertical retorts of refractory material (chamottes), so placed in a suitable furnace that the outside walls are heated by the normal circulation of the hot gases from the hearth. The furnace is charged from above and the coke is discharged at the foot of the furnace. The raseous products are led by a large pipe at the top, whilst the liquid products (tar) flow out at the foot or along the walls and enter a duct into which the upper pipe also discharges its material.

With the aid of an exhaust device, the distillation fumes are directed into an apparatus for slow condensation; the gases not subjected to condensation are led under the hearth for heating the furnace. The tar is generally manipulated in special factories.

The latest tendencies in regard to the utilisation of lignites favour the so-called "internal heating" system by which distillation is effected by means of hot gases.

Certain qualities of lignite are submitted to agglomeration to facilitate transport and increase output. In this case, the lignites, as well as the dust, are dried (usually by artificial means), finely ground, made into a paste with the addition of an agglutinating substance (pitch, tar, resin, etc.), and compressed in moulds for the manufacture of briquettes. In the operations of transforming into paste or of mixing are left out, and only compression takes place.

Amongst the above operations the most harmful is that of grinding, during which great quantities of dust are liberated. The preparation and manipulation of briquettes are less so, since the material is more or less cohesive. The heating of briquettes liberates irritating fumes, since they generally contain pitch and other bituminous substances.

SOURCE OF RISK — PATHOLOGY

The occupational pathology of the workers employed in the lignite industry is to a great extent similar to that of workers in the coal industry. Here again, it is necessary to insist on the fact that medical experts who have made a study of conditions in the coal industry have not included those in the lignite industry, chiefly because the latter merely represent the former in a more attenuated form.

The extraction of lignite (in galleries or in the open) involves danger and risks which accompany all mining work. This explains why there is met with the same effect of heavy work on the cardial-vascular and respiratory systems. The system in general and the blood in particular show harmful effects due to the absence of daylight, to work in a confined space, to bad posture required by lack of space in the galleries (work effected kneeling or lying on the side, and sometimes even on the back). Other harmful effects are connected with conditions favouring rheumatism, draughts, humidity, or at times work in an atmosphere of humid heat.

The quantity of water contained in lignites being fairly high (it sometimes exceeds 50 per cent.) and the lignites being hydroscopic, it follows that there is little dust in the galleries, even in
the case of xyloid lignites, which are more dusty than black lignites. In any case, the quantity of dust is inferior to that produced by other types of coal.

The dry lignites (dried artificially or naturally) disintegrate and liberate much dust. The same disadvantage accompanies extraction of lignites outside the mine or in sheds when the product is freed by the use of a gas for removing surrounding soil. Dust is likewise produced during the manufacture of briquettes.

In certain mines of xyloid lignite, however, dust is liberated to such extent that after an hour's work the worker is quite black with dust. This dust, though constituted by ovoid or polygonal particles, with clean pointed edges, is not very harmful in itself, but may in practice cause damage due to the presence of inorganic particles such as sand and slate, etc.

It is, however, a question of mixed dusts, the harmfulness of which varies from one mine to another, and is in proportion to the degree of humidity of the lignite.

The respiratory lesions caused by this dust are similar to those currently met with among workers in the dusty trades.

The presence of toxic gases is usual in lignite mines: carbon dioxide due to a fermentation process of the product and capable of causing the strata to take fire; methane (fire damp), rare of occurrence, at least in the Italian mines, where fire damp explosions rarely occur (except in the mines of Ribolla in the Grosseto district). At the ordinary temperature in the galleries the lignites do not liberate toxic gases, but in the blasting and cutting sheds small quantities of carbon dioxide are sometimes met with.

The air of the galleries may further be contaminated by gases given off by used fuses from blasting, which sometimes contain very toxic products. Lignite fires are greatly to be feared as a menace to the safety of the workers, for, apart from accidents due to trauma, these fires may give rise to fire damp explosions, and even explosions of the dust in suspension in the air.

As in other coal mines, the combustible itself may spontaneously catch fire apart from explosion due to fire damp, etc., either by friction between two layers of the coal, or by the action of an unduly strong ventilation current on the salient corners at the gallery crossings.

The varying explosion capacity of the dust from bituminous materials is explained by their varying content in carbon dioxide, methane and its homologues. The recent experiments (1926) carried out in Germany have proved that bitumen in dust form constitutes a very explosive element in lignite, and that its explosive capacity is dependent also on the nature and chemical composition of the gases of distillation.

When the lignite catches fire underground, combustion is never complete because of an insufficiency of oxygen. There is, however, extensive liberation of fuliginous smoke of carbon dioxide, carbon monoxide, and sometimes even large quantities of sulphur dioxide, since sulphur is always present in lignite, and likewise of hydrochloric acid, as well as a series of aromatic substances, certain of which cause severe irritation of the mucous membranes.

Lignites have, on the contrary, the property of absorbing the oxygen from the atmosphere, especially when dried and exposed to the air, in which case they absorb large quantities. This explains why the atmosphere of the mines becomes rapidly unfit for breathing; the impoverishment of the air in oxygen due to this cause, in addition to the exhaustion thereof occasioned by the respiration of the miners and combustion of the lamps, constitute a triple cause. It may also be stated that lignites, according to their origin, contain certain impurities such as sulphuretted hydrogen and arsenic (Biondi).

Lignite mines may be infected by ankylostomiasis. In Italy, however, they are generally exempt from this infection (Pieraccini, Giglioli, Biondi, Mori). This fact has been noted also in the Italian copper mines, mercury mines, and pyrites mines, as well as in the lignite mines, despite the fact that certainly more than one miner who was a carrier of ankylostomiasis has penetrated into these mines, without, however, giving rise to an epidemic amongst other miners. No satisfactory explanation of this fact has been found.

It does not appear that handling of lignite, either in mines or industrially, particularly predisposes workers to tubercular infection. Anthracosis, due to lignite, irritation of the respiratory passages by dust, sulphur or other fumes, is generally accompanied by chronic bronchial catarrh, pulmonary emphysema, and disturbance of the pulmonary circulation.

It should also be stated that workers engaged in the galleries suffer chiefly from forms of rheumatic disease affecting the muscles and joints.
When the miner works with his back bare, the dust causes small contiguous patches on the skin, which favour the outbreak of folliculites and dermatites, sometimes extensive and persistent in character. Amongst the hewers there has been noted a conjunctival neformation situated on the right shoulder and due to rapid blows caused by the special tools employed. This lesion is not very important, though cases have been met with in which it showed irritation and gave rise to ulceration (Biondi).

Workers engaged in distilling lignite are exposed to injuries peculiar to the products described above. Nevertheless, medical literature contains no case of poisoning or of lesions among these workers. Lignite tar, and in particular certain of its distillation products (crude paraffin), have given rise to several cases of cancer. The first was studied in a tar distillery in the region of Halle (Saxony) in 1873; 3 further cases were described in 1875 by Volkmann; and other cases by Tillmanns (1880), Schuchardt (1885), Liebe (1892). The cases in question were designated by these authors as "paraffin cancer". It should, however, be recalled that the paraffin produced at this time was highly impure and contained other tar products which the workers were called upon to manipulate. Kennaway, who in 1923 resumed the study of the occupational cancer problem, revealed the fact that the cases due to lignite tar, and described in literature, amount to 10 (1873 to 1890), 7 of which were situated on the scrotum, 2 on the arm, to -10 (1873 to 1890), 7. of which were tar, and described in literature, amount to manipuJate.

Products which the workers were called paraffin, (Biondi). Other cases by other authors (1880), Schuchardt (1885), Liebe (1892). The cases in question were designated by these authors as "paraffin cancer."

The lesion is not very important, though cases have been met with in which it showed irritation and gave rise to ulceration (Biondi).

In conclusion, work with lignite may be considered as very slightly prejudicial to the health, and at least less harmful than the manipulation of other kinds of coal. The most important risks are those of a general character rather than of a particular order connected with the lignite industry, for it is more a question of the subterranean work causing physiological exhaustion, which is characteristic of workers in this industry. In fact, coal miners present the highest invalidity percentage, higher even than that of the workers in metallurgical trades who, nevertheless, have high invalidity rates. Lignite workers, on the contrary, show the lowest percentage among miners in general (Castellani).

The hygienic measures recommended are those to be found in the article entitled "Mines (Hygiene in)."

Legislation is similar to that for coal mines (see articles "Mines (Hygiene in)" and "Miners' Diseases").

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LIME

French: Chaux; Chauv vive; Oxyde de calcium. — German: Kalk; Aetzkalk; Kalkerde. Calciumoxyd. — Italian: Calce; Calcina; Osso di calce. — Spanish: Cal; Protoxido de calcio.

Pure calcium oxide (formula, CaO) is a solid substance (density, 3.4), amorphous and very refractory, which fuses at 2,750° C. and only volatilises at the temperature of the electric furnace. It absorbs moisture with avidity and is converted, in the presence of water, into powdery calcium hydrate ("slaked lime") with much disengagement of heat in accordance with the formula, CaO+H,O=Ca (OH). This is the reason why lime exposed to moist air becomes reduced to powder — "slaked".

Derivatives of lime form the greater part of the earth's crust. From the technological point of view, various kinds of lime are used in industry and for building purposes;
**Fat lime.** — A pure lime, white, caustic, obtained by calcining a pure chalk (containing no clay). It owes its name to the property it has of yielding, with a sufficient quantity of water, a very fine, rich, abundant paste.

**Lean lime.** — Obtained by calcining impure chalks containing from 5 to 12 per cent. of clay or silica, as well as, in general, a little magnesia, oxide of iron, and clay. On contact with water, it yields a short and rather sparse paste.

These two varieties of lime constitute the air-slaked limes which, mixed with water, do not set except on exposure to air by the formation of calcium carbonate from the carbonic acid gas of the atmosphere.

Hydraulic limes are made by calcining chalks containing from 12 to 20 per cent. of clay (natural hydraulic lime) or artificial mixtures of clay and chalks in suitable proportions (artificial hydraulic lime). They are characterised by their property to set under water which is the more rapid the more clay they contain.

**INDUSTRIAL PROCESSES**

**Air-Slaked Limes**

Lime is obtained by calcining chalk or limestone at about 1,000° C. in two kinds of furnaces: intermittent and continuous. Intermittent furnaces, still used in small works near chalk quarries, supply the lime needed locally for agricultural and building purposes. They consist of a chamber in masonry with ovoid cavity and lined internally with bricks of refractory materials. Changing is effected through an upper opening or mouth; emptying at the lower part where the hearth is situated. First there is built a roof of large stones; then stones of diminishing size are introduced through the mouth in order to fill the kiln. The kiln is heated with wood, peat, or coal. The operation lasts about forty-eight hours; at the end of this time the kiln is allowed to cool and is completely emptied with the spade from an eye at the bottom. The continuous kilns allow manufacture to be carried on without any stoppage, charging being done about every twelve hours from above and discharging from below. They are of two kinds, with a short and long flame.

Modern works adopt especially kilns with short flame with certain improvements which, while economising hand labour and increasing output, greatly diminish risk to the health of the workers. In these kilns the charging made through the mouth comprises alternate layers of chalk and fuel. It is set alight from an internal hearth, which is not set in action except at the moment of starting.

Among recent models, the Candiot kiln is provided with a hood and counterforce covering the mouth and being able to slide alongside a chimney, which ensures sufficient draught to protect the workmen against the escape of smoke and hot gases even during charging. The lower part consists of a grill in the form of a basket. Emptying is thus done automatically by the pressure of the materials, the workman only having to intervene from time to time to facilitate the fall of the lime by means of a long rake.

The Maenstaedt kiln, entirely automatic, receives the chalk and fuel by a mechanical transporter, whilst to empty it a valve controlled by a counterpoise is used. The lower grid consists of cylinders of cast iron which by means of a rotatory movement, obtained from an electric motor, allows of automatic emptying and at the same time crushes the lime, which falls on to a mechanical transporting arrangement. Two valves moved alternately prevent direct communication between the inside and the outside of the kiln. The air necessary for combustion is blown in by a fan. These modern kilns allow of the recovery of the carbonic acid gas given off during the reaction.

The quicklime as it leaves the kiln oven (lime in cakes) is placed in barrels in this state or after slaking (see below Hydraulic Limes). It must be kept away from the air because it fixes the carbonic acid gas and regenerates the carbonate of lime.

**Hydraulic Limes**

Clayey chalks or mixtures of chalk and clay are baked in a continuous kiln with short flame.

The chalk and clay, in this case, are first ground by a mill in a vessel full of water. The mash thus formed is allowed to rest; the greater part of the water is removed by decantation; then the paste is divided up into sections, dried in the air, and carried to the kiln.

The Teil kiln is also used. This consists of a great ovoid shaft with a mouth at the upper part and an opening at the bottom provided with a grill, under which is the discharging gallery. A cone made of iron bars (mantle for air distribution) placed in the centre of the grill facilitates the ascent of air and the descent of the baked lime, which falls into the bogeys placed in the gallery underneath.

After baking, sorting of the pieces is carried out to separate the "well-baked" from the "unbaked" (which
go through the kiln a second time) and the "over-baked".

Hydraulic lime is always slaked with the object of making it absorb a rigorously determined quantity of water, so as to cause it to pulverise en masse (commercial form) by converting the quicklime into slaked lime. This operation can be done by hand, either with a sprinkler or nozzle. The lime is generally arranged on the ground in heaps 20 cm. high, which are watered. This method, however, presents so many technical and hygienic defects (disengagement of dust) that for a long time automatic slaking has been done with apparatus (Schultess apparatus, for example) yielding a quicklime in the form of a fine, dry powder easy to sieve.

The slaked lime is then crushed, ground, and finally sifted. The first sifting yields light lime; what is rejected is crushed and yields, after a second sifting, "commercial lime", and as rejected material a non-pulverulent residue, which is left for several months in silos, where it undergoes hydration and becomes pulverised. A final sifting yields "heavy lime"; the residues in this operation are again crushed and sifted to be used in the manufacture of certain cements.

The lime is conveyed to different parts of the works either by means of trollies or mechanically (travelling belt, Archimedean screw, etc.) until it is bagged or packed in heavy sacks (Schultess apparatus, for example) yielding a quicklime in the form of a fine, dry powder easy to sieve. The emptysacks of lime are returned to the factory, where they are again opened, bagging, barrelling, carrying, handling, employed in crushing, grinding, sifting, etc., especially if the work is done by hand.

Kiln chargers, further, have to do arduous work (carrying and handling the raw materials). The slakers are exposed to the action of dust when the work is done by hand. The lime dust is very fine, since with a 4,900 mesh to the square centimeter, 90 per cent, goes through, and is the basis of dust when the work is done by hand.

**Uses**

Lime is used either by itself or in the form of milk of lime.

- **Solid lime** is used in the following operations and industries:
  - Manufacture of cement; building industry (cementers, plasterers, white-washers, slakers of lime, rough casters, paperhangers, etc.); subterranean works; manufacture of calcium carbide by the electric furnace using a mixture of lime and coke); of chloride of lime and chloramines; in tanneries (dehairing of skins by means of a mixture of quicklime and orpiment); in dyeworks (as a decoloriser); in the manufacture of synthetic colours; in electroplastic work (for cleaning the pieces with a brush: mixture of pulverised lime and oil); in metal polishing (to keep the surface of the metal dry); in agriculture as a manure, etc.

- **Milk of lime** is used every time a strong and cheap base is needed in the following industries:
  - Manufacture of soda by the Solvay process, of caustic soda and potash, ammonium, sugar, soap, stearine candles, etc.; in gas-works (for purifying the gas), dye-works, the textile industries (preparation of the textile fibre before dyeing or printing, boiling the fibre in an alkaline solution containing milk of lime), etc.; in agriculture, etc.

**Sources of Danger**

(a) *In the course of manufacture.* — The stokers charged with filling the kiln, looking after the fire, regulating the air currents, etc., are exposed to the action of high temperatures, of brisk changes in temperature, to toxic gases (carbon monoxide, carbon dioxide, sulphur dioxide, arsenuirreted and sulphurretted hydrogen gas, etc.), especially when the draught is insufficient or defective; to dusts, etc.

Kiln chargers, further, have to do arduous work (carrying and handling the raw materials).

The slakers are exposed to the action of dust when the work is done by hand. The lime dust is very fine, since with a 4,900 mesh to the square centimeter, 90 per cent. goes through, and is the common risk for all the workmen employed in crushing, grinding, sifting, bagging, barrelling, carrying, handling, etc., especially if the work is done by hand.

(b) *In the course of its use:* see above.

(c) *In the course of the manufacture, and manipulation of products containing lime as an impurity:* basic slag (which contains up to 20 per cent. of quicklime); Swedish matches (dust with a high percentage of caustic lime); calcium cyanide (see that article), which contains up to 21 per cent. of quicklime (injurious to persons using it, e.g. agricultural labourers); spathic ores (carbonate of iron, manganese, lime), when discharging from the holds of ships (the particles of lime mix with the sweat and irritate the uncovered parts of the skin; they set up also lesions of the mucous membranes).
INJURIOUS ACTION

The action of quicklime is due partly to its avidity for water (dehydration), to the heat given off in its reaction with water, and partly to the peculiar causticity of the alkaline oxides or alkaline earths. Quicklime exerts essentially a local action (on the skin and mucous membranes), irritating and caustic, which is naturally less marked in the case of slaked lime. Milk of lime is a feeble caustic acting only on the mucous membranes. The dilute lyes are only caustic to the skin after prolonged action and especially when they are warm.

In practice it is the dust of quicklime and slaked lime, given off in the course of manufacture and manipulation, which gives rise to the well-known lesions. This very fine dust is deposited readily on the mucous membranes and skin; when inhaled it may penetrate as far as the respiratory tract.

STATISTICS

An enquiry, although not recent, was made by Rota and Finzi (1906) among the workmen in the lime and cement factories of Casali Monferrato (Piedmont). While conditions in the getting of lime-stone were not good: bad ventilation, variable temperature, and humidity of the galleries, etc. The men ran considerable accident risk, and among the maladies to which they were exposed were rheumatism, neuralgia, burns, and respiratory troubles.

Kiln men working in a temperature reaching 1,600–1,900° C. showed a morbidity especially from respiratory diseases (bronchitis, broncho-pneumonia), rheumatism, and, in summer, diseases of the digestive system due largely to the drinking of water to allay thirst. Under certain conditions, especially hereditary influences, morbid respiratory states prepare the soil for tuberculous infection. The workmen most exposed to dust were naturally those engaged in grinding the lime or cement, bagging, barrelling, and loading into trolleys.

According to these investigations, lime dust was considered more injurious than that of cement, because of the chemical and mechanical action it exerts on the skin and mucous membranes.

Morbidity data collected during several years among workmen either at their work or in hospital did not suggest that this class suffered any high morbidity. At the same time respiratory diseases, including tuberculosis, were the most frequent especially among the kiln men. Rheumatism and infections (principally typhoid fever) come second. Mortality figures show that respiratory diseases are the most important cause of death. Pesenti (1906), however, takes the view that there is a form of pseudophthisis, a chronic pneumoconiosis, which might be often diagnosed as tuberculosis.

Rota and Finzi emphasise the fact that many of the workmen they examined had worked from fifteen to thirty years and more in lime and cement factories without having been ill. This resistance to illness, even to lung disease, is a very striking characteristic. It is certain, however, that the daily inhalation of irritating dusts must slowly and progressively damage the air passages and that the effect of this must be to lead to some deleterious effect on the health of the individual. This fact explains why so few workmen reach an advanced age.

These writers were of opinion that from 1906 it would be advisable to exclude from the industry applicants affected with arthritis, epilepsy, and predisposition to respiratory diseases, especially pulmonary tuberculosis.

In Switzerland lesions due to lime or carbide of calcium reported to the National Accident Bureau numbered 14 in 1918, 5 in 1919, 3 in 1920, 5 in 1921, 5 in 1922, 5 in 1923, 3 in 1924, and 2 in 1925 (slaked lime had set up 3 cases of dermatitis).

PATHOLOGY

Lesions of the Skin

Like all dermatites, those set up by lime are favoured by certain individual factors (see article "Skin Diseases"). In appearance they show themselves in many forms and may assume the exfoliative type (the most frequent: it begins with a rash of more or less distinctly follicular distribution, red, weeping, sometimes with patches of fine desquamation, followed generally by a non-irritating papular eruption); vesicular (sometimes confluent and situated mainly on the back of the hand); pustular folliculitis (with thickened skin, dull, cracked, dry, with fine scales, sometimes with fissures at the base of the folds of the skin, especially the joints); seborrhoeic: erythrodermic (more or less generalised), etc.

In the manufacture of carbide, typical ulcers are met with, neatly punched out through the whole thickness of the skin; intertrigo; deformity of the nails (see article "Skin Diseases").

These dermatites always cease when the workman leaves the harmful influence. Usually they are not serious, but cases which relapse are known, so severe as to entail permanent incapacity.

The aetiological diagnosis is sometimes difficult because the patient cannot give precise details of his work, and it is often necessary to study carefully the materials handled in order to determine exactly the nature of the substance with which he has been brought into contact.
Lesions of the Mucous Membranes

The most frequent are those of the conjunctiva and cornea, due either to solid particles or splashes of the liquid entering the eyes.

Caustic action rarely occurs from quicklime because the workmen know the danger they run and take the necessary precautions. Burns from slaked lime are more frequent or from mortar or plaster, the caustic action of which may continue for several days. It is this long contact which explains the gravity of the lesions. It may lead to scarring.

The smallest particle of lime in the eye causes spasmodic closure of the pupils, copious lachrymation, which favour the spontaneous expulsion of tiny bodies from the eye but, in this particular case, is not advisable because closure of the eyelid compresses the particle of lime against the eyeball. The lachrymation, it is true, slakes the quicklime, but the heat given off in the reaction increases the destructive process and may lead to perforation of the eyeball. Cicatrization takes place generally with eversion of the eyelids: entropion or entropion, trichiasis (turning in of the eyelashes), and even syntropion.

Hoppe gives 282 cases of ocular lesions among which are the following: masons 122; cleaners of walls and ceilings, 64; porters carrying lime, 26; makers of mortar and lime, 19. On the buccal mucous membrane the lesion is generally characterised by small ulcers, itching rather than painful, rarely lasting, and appearing as white points surrounded with a red margin. The lesion has a transparent mililiary aspect. These phylctenular ulcers which break leaving an abrasion are situated generally on the anterior pillars of the palate, on the outside of the tonsils, on the uvula, etc. If the workman gives up his work they yield in twenty-four hours to simple gargling with ordinary or alkaline water. If he continues at his work the number of the abrasions increases but more superficially than in depth. Pain, with difficulty in swallowing, accompanies them. The mucous membrane is rarely stripped off and rarely bleeds (Fabri).

Ulceration of the nasal mucous membrane has been described, and, more rarely, perforation of the septum.

The deeper respiratory passages are rarely reached by the dust of lime, which sets up principally cough and sneezing. But cases of pneumonia due to inhalation of these dusts have been described.

Experience and the recent studies of Roessle have equally shown that workmen handling lime are relatively little attacked by pulmonary tuberculosis. Kiln men are said to have a mortality from tuberculosis less than the average. (See above, Statistics.)

The high temperatures, watching the fires, brusque changes in temperature, the hard work entailed in charging (when done by hand) and discharging show their effects in various morbid conditions such as bronchitis, affections of the lungs, joints, circulation (varicose veins, etc.), indigestion (due to the heat and excessive drinking of liquids), etc.

Cases, often fatal, from poisoning by carbon monoxide are described among workmen who have gone to sleep on the top of lime kilns. Severe caustic burns have been described in workmen who had fallen into a lime pit. Death has then resulted from extension of the lesions.

Hygiene

Lime kilns should be built away from centres of habitation and should, if necessary, be surrounded by a wall of masonry to serve as a screen.

Kilns connected to a chimney stack should be provided with strong draught. The charging level should be that of the surrounding ground so as to avoid all accumulation of poisonous gas at levels dangerous to the workmen. Measures should be taken for protection against radiant heat and escapes from the hearth and smoke. If the fuel used is not coke, very objectionable smoke is given off. Premises using lime kilns built with a view to the manufacture of liquid carbonic acid gas generally burn the carbon monoxide, so that inconvenience from these gases is avoided. On the other hand the airtightness of the apparatus and pipes along which the gases travel should be periodically tested and any escape of carbon monoxide, etc., stopped. Good ventilation should be maintained in every works, and all cul-de-sacs, pits, etc., where asphyxiating gases might accumulate should be avoided.

The raising of any dust should be as far as possible avoided by using closed apparatus provided with exhaust ventilation: Davidson's finishing tubes, centrifugal crushers, special kinds of sifters, etc. A slight negative pressure should be maintained round the apparatus, which should be covered with large enough hoods; bagging and barrelling should be done by automatic means (see article "Dusts"). The quantities of smoke which escape from the kilns should be as far as possible
freed of dust, which should be recovered by the different methods in use (bafflers, Beth filters, depositing chambers, etc.). Hand work should be replaced by mechanical work wherever possible.

The lime should be barrelled or removed immediately after it has been cooled. Unnecessary noise and vibration should be diminished or suppressed.

Personal hygiene resolves itself into wearing respirators (moist sponges), plugs in the ears, leather gloves, overalls and caps. The workmen are in the habit of smearing a little fat on the hands and repeating the application on the skin of the hands and arms even during the night, which is an excellent precaution. Personal cleanliness, change of linen and underclothing after work, and bathing are most desirable.

Treatment of burns to the eyes lies with the medical man. The particles of lime should be immediately removed or neutralised to prevent in good time injurious effect. Later treatment (Nedden) comprises daily irrigation for fifteen minutes with a 10-20 per cent. solution of neutral tartrate of ammonium. Nowadays the use of sugar and water, which was formerly recommended, has been abandoned because it came to be recognised that the saccharate of lime formed is extremely caustic.

LEGISLATION

Women are prohibited from work in lime kilns (crushing and riddling the stone) in Argentina; in grinding and sifting in the Netherlands. When the dust created during crushing, sifting, etc., is not removed by a mechanical process young persons of under sixteen years of age are prohibited by law from working in Belgium and Spain; under eighteen years in the Netherlands and France; under fifteen in Italy, as well as employment of women of under twenty-one in Spain, Italy, etc.

Special regulations for work in lime kilns have been issued in Austria (sections 8 and 12 of the Order of 1911 on work in sugar factories). German legislation takes account of the risk from lime in the Order of 1911 on the manufacture of chromates. The French Industrial Code, as well as the Austrian regulations referred to above, prohibit sleeping on the top of the kilns. A Norwegian Royal Decree deals with the processes of grinding and pulverising limestone. Certain statutory preventive measures have been issued in regulations dealing with the manufacture of cement.

ECzema and dermatitis due to lime are compulsorily notifiable in France and in the Netherlands (in premises for slaking and sifting); compensation is awarded as in the case of industrial diseases in Finland and Switzerland. Compensation for these lesions is also given in countries mentioning, in the list of scheduled diseases, lesions of the skin and mucous membrane due to dust or liquids.

BIBLIOGRAPHY


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Litharge

French: Litharge. — German: Bleiglätte. — Italian and Spanish: Litargiro.

CHEMISTRY

Litharge (crisite, argirite) is a protoxide of lead (PbO) which is sometimes found in nature. The name, however, is reserved for the refined product, that of "massicot" (Germ. Bleigelb) is given to the calcined but unrefined product.

These substances are fusible at a red heat (880° C.), insoluble in water, readily soluble in dilute acetic and nitric acid as well as in the gastric juice. They dissolve in hot caustic potash, from which they crystallise out on cooling in the form of rhombohedral crystals.

Litharge has a yellow, sometimes a reddish colour, and is crystalline and laminated. According to the shade of colour it is known under the name of golden or silver litharge. Massicot is a soft amorphous powder of yellow colour.

MANUFACTURE

On heating metallic lead in contact with air, according to the temperature either litharge or massicot is obtained. The former is the important product of the cupellation of silver, and is obtained also on roasting galena and treating it then by soda or by calcining the carbonate or nitrate. Industrially, litharge and massicot are obtained during the melting of lead. This operation is carried out on the floor of a reverberatory furnace heated to 450-500° C. in contact with air. The lead is introduced in pigs of 50 to 100 kg. weight, and as soon as it melts the surface is constantly kept stirred to increase the oxidation and the layer of oxide floating on the surface skimmed off. This rabbling is done with a rake either by hand or mechanically. It would seem as though mechanical methods would altogether replace those by hand.
Dangers. — The great heat of the furnace predisposes to poisoning from lead fumes, but their injurious effect can be lessened by hoods with exhaust draught and provided with a pipe, allowing a spray of water to be projected between the workman and the furnace door. This latter precaution, however, is not always practicable. The workers, further, should be protected against the lead dust escaping from the furnace when the pigs are introduced, during fusion, and when the layer of oxide formed is removed. The amount of dust removed is very considerable.

Emptying the furnace. — This is a very arduous task and one of the most dangerous. The oxidised dry material is removed from the furnace by shovels or rakes and emptied into a trolley, which conveys it to the cooling bins.

The lead fume given off in great quantity from the extruded mass should be carried away by a hood arranged above the opening of the furnace door connected with a duct going above the roof. Such protection seems efficacious. Analysis of 90 litres of air in an Austrian works taken at the time of emptying showed traces of lead (less than 0.1 mg. estimated as oxide of lead).

The trolley when filled is ready to be moved; its contents are moistened with water poured carefully on them, the workman should wear a wet sponge over the mouth. The wearing of a respirator is always difficult to secure.

The deposition of dry matter on the floor in the cooling bins should be prohibited.

The dry material is then ground and washed to separate the protoxide from the metallic lead. This operation is carried out in vats under a stream of water either by hand or mechanically. The product is next dried again, is pulverised, sieved, and packed. All these processes are naturally attended with great risk because of the lead dust raised as they are done. All necessary measures ought to be taken to prevent the escape of dust into the atmosphere of the workroom.

Use

Litharge and massicot are used in the manufacture of red lead, of nitrate and peroxide of lead, of nitrites, white lead, in glass, in optical glass, in crystal, in paste, in pottery glaze (decoration); as a flux in painting on porcelain and on glass; in the manufacture of putty and varnishes; for accumulator plates, in rubber; as a drier of oil varnishes; in pharmacy for making lead plaster; in the manufacture of painted papers, and in the form of plumbite (compounds of alkalis with peroxide of lead); as mordanting agents.

TOXICITY

Massicot and litharge, being soluble in the gastric juice, are among the most toxic of lead compounds. Experiments on animals show that small quantities produce fatal results in a short time (a few weeks). While the minimal fatal dose for white lead is fixed for animals at 10 grm., that for the oxides is a little higher, but not more than 20 grm. The toxicity depends evidently on the form in which it is taken. In laminated form it is less toxic than as powder, because the former is less readily absorbed.

Statistics

Statistics are not available for workmen employed in making these two substances. Generally, they are classed with persons employed in melting lead. As to those engaged in using litharge in various industries, it will suffice to cite the case of a woman in a scent factory in Germany in 1913, who used a paste made of litharge; of a workman making electric insulators in Austria, 1913; and a case among workers in Great Britain making electric accumulator plates and rubber articles. (See the Medical Inspector's reports for Great Britain, 1914-1918 and following years.)

Symptoms

See article "Lead Poisoning".

Hygiene — Legislation

For notification, compensation, etc., see the articles "Lead Poisoning", "Lead", and especially "Red Lead".

Bibliography

See the articles mentioned above.
Lithopone


TECHNICAL DATA

Lithopone, also known as zincolith, Griffith’s White or Charlton’s White, is a mixture of zinc sulphide and barium sulphate, obtained by the hot precipitation of barium sulphide and zinc sulphate solutions.

Unlike white lead, it is not toxic, and is not affected by sulphuretted hydrogen.

Barium sulphide is obtained by bringing to red heat barytes or heavy spar, mixed with coal, in revolving furnaces. The mixture of sulphide and barium oxide formed is dissolved in filtered water, and the filtrate is treated by sodium sulphate. Barium sulphate is thus precipitated and caustic soda remains in solution. The process can also be effected by stirring with barium carbonate which is dissolved in hydrochloric acid. It is precipitated by sodium sulphate or dilute sulphuric acid in a cold state.

The Chemical Service of the Dutch Factory Inspectorate found traces of arsenic in samples of barium sulphate.

Preparation of zinc sulphate. — Zinc oxide in the form of powder, produced from all kinds of waste, mixed with water in closed mixing troughs till it has become a thick fluid mass, is poured into a stirring tub, in which, by the addition of sulphuric acid, zinc sulphate is obtained. After neutralisation of the excess of sulphuric acid, the mixture is filtered in filtering presses. The residuum, which contains a considerable amount of lead (17 to 40 per cent.), is washed out, dried up to the point beyond which it would give out dust, and sold for the manufacture of lead. The zinc sulphate solution is again purified twice in stirring tubs: with potassium per-manganate for the removal of iron, etc., and with zinc powder for the removal of arsenic, etc. The zinc sulphate dissolved in water is then filtered in filtering presses.

Instead of oxide of zinc, crude zinc sulphate is sometimes used. This contains amongst other impurities lead, 30-40 per cent. of which remains in the residue.

The Chemical Service of the Dutch Factory Inspectorate found about 1 per cent. of lead and traces of arsenic in a sample of zinc sulphate.

Preparation of lithopone. — A hot solution of zinc sulphate is precipitated with a hot solution of barium sulphate, the white precipitate is filtered, and there is added thereto a freshly precipitated hydroxide of magnesium. The mixture passes to the filtering presses, is thoroughly washed, dried and pulverised. It is mixed with ammonium chloride, brought to red heat, and, while still hot, cold water is poured on it. It is then filtered, dried, and finely ground. The mixture obtained contains, according to the kind of lithopone, 11 to 42 per cent. of zinc sulphide. There are other processes of manufacture which it is not necessary to describe here. The Chemical Service of the Dutch Factory Inspectorate has found traces of lead and arsenic in a sample of the lithopone.

No injuries to workers engaged in lithopone factories are known, save those reported by the German factory inspectors: one worker attacked by gastric pains and hemiplegia of the right side died after having handled a mixture of barium peroxide (44 per cent.) and barium carbonate (56 per cent.); the post-mortem examination revealed the presence of barium in the organs (0.5 grm. in the stomach and intestines). Hygiene experts have drawn attention to the strong toxic effect of the peroxide, which is readily soluble in water and effects its action without the necessity of the presence of a dilute acid as is the case for barium carbonate.

In 1924 in a factory of chemical products several workers engaged in handling the residues from lithopone manufacture in preparing cadmium were poisoned by the fumes. The enquiry revealed that the fumes in question were cadmium fumes rather than arseniuretted hydrogen. Of the ten workers attacked one died.

In 1925 cases of poisoning were met with under similar conditions in another German factory: of five workers affected one died. In this case the enquiry proved that poisoning was due to arseniuretted hydrogen, the arsenic being present either in the zinc or in the sulphuric acid used.

HYGIENE

In shooting the powdered zinc oxide from sacks into the hoppers of the stirring tubs, a considerable amount of dust is raised, which, by reason of its lead content (1-5 per cent.) and traces of arsenic (see these articles), constitutes a danger to the worker.
Requisite measures should therefore be taken to avoid liberation of this dust. The cleaning of the empty sacks should be carried out in a closed apparatus by means of suction.

The raw zinc sulphate is conveyed in tip-trucks from the store rooms to the tubs. A considerable amount of dust is produced in loading and unloading, especially in dry warm weather.

In filtering the zinc sulphate in the presses, a dust is left in the press-cloths, which contains about 30 per cent. Pb SO₄. Formerly these cloths were scraped with a small shovel. The new filtering presses are now provided with a rinsing arrangement by which contact with the hands is avoided.

The conveyance of the barium sulphate to the revolving furnaces is carried out automatically in a closed apparatus, as also is the conveyance of the barium sulphide.

The sulphuric acid is conveyed by *morte jus* from iron boilers by leaden pipes into the stirring tubs. In cleaning these reservoirs the worker, before going in, introduces marl (clay+lime), which is afterwards forcibly syringed with water.

**Prophylaxis**

Attention should be drawn to the wearing of gloves and respirators as a protection against contact with dust containing lead or arsenic.

**Legislation**

See article "Zinc."

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Malaria

French: Paludisme. — German and Italian: Malaria. — Spanish: Paludismo.

Malaria is a widespread disease in many temperate regions but especially in tropical countries. It is characterised by intermittent obstinate fevers which have a tendency to become chronic, and is accompanied by grave general disturbances and organic lesions which make this infection an important cause of physiological and economic misery in many centres of population.

There are three types of malaria: benign tertian, quartan and malignant tertian, and these three types are caused by three kinds of parasite: *Plasmodium malariae*, *Plasmodium vivax*, and *Plasmodium falciparum*.

These parasites are protozoa and, more precisely, protozoa working out their cycle of development in two different hosts: man and mosquitoes of the genus *Anopheles*.

In man the sporozoites, inoculated by the bite of the mosquito, undergo a sexual evolution which provokes the access of fever, recommencing periodically and finishing by the formation of sexual elements or gametes which can only continue their evolution in the body of the mosquito. When this has sucked them in with the blood of the malarial subject the sexual evolution commences by the fertilisation of the gametes, with which is associated the formation, in the intestinal wall of the mosquito, of an egg or zygote, which passes through the walls of the digestive tract and has been given the name of "oöcyst". Inside it are produced "sporozoites", that is, very small parasites which, on the rupture of their cyst, later invade the salivary glands and from there, when the mosquitoes bite the man's skin to suck the blood, they pass via the proboscis and enter the human organism with the saliva.

It is impossible to describe these phenomena in detail here. It will suffice to remark that wherever malarial subjects exist, whose blood contains sexual organic elements and at the same time the anopheles are able to suck the blood, the evolution of an epidemic of malaria is possible; but this possibility is not always realised because it demands the presence together of several circumstances such as: a temperature sufficiently high; a certain surrounding humidity to enable the sexual cycle of the parasite to develop in the mosquito (hence there is a seasonal condition for this in temperate climates which, on the other hand, does not exist in warm countries, where the disease is observed all the year round); a number, and that not too small, of malarial subjects and anopheline mosquitoes.

The disease is not effectively transmitted unless the malarial subject has gametes at the point necessary for development passing into the stomach of an anopheles mosquito which can live sufficiently long to allow of the evolution of the sexual cycle and inoculation of a healthy man with a sufficient number of parasites. The well-known factor of the presence of anopheles and malarial subjects in certain localities without the occurrence of an epidemic makes these regions become known as areas of "anophelism without malaria". There are, however, some districts where the generalisation just given does not appear to be sufficient because the anopheles may have adopted different modes of life, no longer caring, or unable, to bite men; but it is necessary to add that these are only hypotheses which require proof.

The anopheles (females) do not necessarily require human blood for the evolution of the eggs in a normal way; they can gorge themselves with blood of other mammals, the presence of which near man may thus be able to prevent his being bitten by mos-
quites and thus diminish the chances of malarial infection.

Although this malady can be conveyed by different kinds of anopheles, the most formidable are those that are called "domestic", because they pass a part of their lives in houses where excellent conditions exist for biting man. The wood-haunting species, as well as other domestic species, have fewer opportunities of biting man except when he is sleeping in the open air; furthermore, even those which infect themselves as just on the multitude of others and there is consequently little probability of their succeeding later in transmitting the malady to healthy men.

All the inhabitants of a malarial locality are exposed to occupational risk which is greater among certain classes. Those in easy circumstances, having relatively good accommodation, are less affected by anopheles. They live generally in the upper floors which are less accessible, and they can protect themselves against the bites by means of netting on the windows or mosquito curtains round the beds.

The risk is still less if the houses are remote from stagnant water or if the latter has been properly treated.

On the other hand, the peasant class inhabiting slums infested by the anopheles, who are sleeping as other workers may do in the open, or having to spend night hours outside their houses, and, lastly, many other persons whose organic resistance has been lowered by poverty, are more susceptible to contract the disease. Shepherds, soldiers, railwaymen and workmen engaged on sanitation enterprises, miners and generally all those who are badly housed, badly nourished and employed on arduous or unhealthy work are rendered the more susceptible in consequence. An important role is played in their case by ignorance and prejudice, which constitute an obstacle to many measures of social and individual reform.

The disease, of which the average incubation period is ten to twenty days and even more, is characterised by attacks of fever in which the temperature rises to 40-41° C. for some hours, but it recurs, according as the fever is quartian or tertian, at regular intervals of four or three days. The attacks recur at irregular intervals of three days or even less in tertian, malignant or tropical fever; the regularity of the attacks is not always maintained and may be absent because of the simultaneous presence in the patient of two kinds of parasite or of different generations of a single species, which have been developed by multiple and successive infections. Two other important symptoms are anaemia and enlargement of the spleen.

Malaria is a tenacious malady. Often, even in cases which have received adequate treatment, the fever reappears with all the other symptoms after a certain period of apparent health.

It is the frequency mainly of such relapses that characterises chronic malaria accompanied by increasingly severe anaemia bringing in its train profound organic debility (malarial cachexia). Malaria does not always present itself in the recognised typical clinical picture; more or less severe and atypical morbid phenomena affecting different organs then predominate in the clinical picture.

Finally, in certain cases the disease appears with symptoms of such gravity and so suddenly that the life of the patient is immediately in danger (pernicious attack).

A complication of malaria which may entail high mortality and which deserves mention is haemoglobinuria. It is said to appear sometimes as the result of an intolerance towards quinine or other remedies administered to the patient; it may also occur in direct relation to malarial infection or may be a morbid condition in which malaria is active as a predisposing factor.

No certainty exists of any real congenital or acquired immunity to malaria, but several facts nevertheless tend to show that the inhabitants of malarial regions resist the consequences of the infection better than immigrants from other countries. It may be that there are exceptional cases of complete immunity.

Diagnosis should be based normally on microscopical finding of the parasites. If they are not numerous or practically absent, recourse may be had to different methods of observation — examination of large drops of blood instead of the usual films; stimulating the passage into the blood of parasites which may be embedded in internal organs, a method which, however, has not yet been applied in a satisfactory manner, etc.

The prophylaxis for malaria is extremely complex and difficult, especially in cases where conditions are favourable to widespread dissemination of the virus. The principal bases for this prophylaxis are as follows:
(a) Direct Measures against Human Infection

(1) Radical treatment of the sufferer until a complete cure is effected, which is the easier the earlier treatment is begun. Availability of all means of treatment; very close control in order to reveal as soon as possible new cases of infection rendering infection by mosquitoes less and less frequent.

(2) Mechanical protection of houses by means of netting and mosquito curtains, periodical capture and destruction of mosquitoes in houses where this mechanical defence fails.

(3) Quinine prophylaxis which should be welcomed confidently; but it should be noted that if it is not well and regularly administered, as is often the case among a large population, it is not a sufficient safeguard.

(4) Combating by all means physiological and economic poverty, as these constitute conditions favourable to the occurrence and aggravation of malaria: improving the living conditions of the population; giving them clean and well-ventilated homes, etc.

(5) Enlisting the whole of the exposed population in the effort to combat malaria, with, as a consequence, the necessity for instruction and education in this sense.

(b) Direct Measures against the Mosquito

The existence of anophelism is linked up with local conditions, represented principally by stagnant water or water courses where the current is not sufficiently strong or clean and contains vegetation. The life of the mosquito varies according to its species; while certain mosquitoes can develop in pools of water formed by the rain, in the trunks of trees or in receptacles that have been thrown away, others prefer fresh and more abundant water. The fight against anophelism therefore demands a precise knowledge of the species in each region, as well as of their special habits; a well-distributed water supply; suppression of stagnant water by assuring a regular and sufficiently rapid flow in watercourses; combating plant growth; which is the cause of obstruction in the flow; and finally the control of river banks so as to prevent the formation of marshy land. All this is comprised under the name of "good drainage". The majority of the large-scale measures for improving sanitation only assist indirectly in improvement of the country from a sanitary point of view, by tending especially to restore the agricultural value of land hitherto uncultivated as a result of bad distribution of water. An economic improvement follows and conditions of life of the agriculturists improve, enabling a more or less extensive gain, according to numerous concomitant conditions, to be made on the malarial enemy.

These indirect benefits, often slow to show their effect and so often incomplete, become more marked and of greater importance if, in their execution, account is taken of the sanitary aspect as well as of the general principle laid down as to the distribution of water.

A host of useful measures, which may be designated matters of detail, include activities of less importance and of various kinds, the object of which is to favour the drying up of small reservoirs or expanses of water, especially around villages, or of modifying river banks, channels, ditches, etc., in such a way as to avoid hindrance to currents and formation of marshes. In this connection mention ought to be made of chlorination of dangerous water to a limit above that supported by malarial larvae, its treatment with petroleum or other toxic substances in solution or powder, destruction of surface-feeding fish, periodical emptying of irrigation reservoirs, periodical drying of ditches, etc.

LEGISLATION

Discussion on the question of whether malaria is an accident or an industrial disease has caused much ink to flow in Italy. It is true that the report on the Accident Compensation Act stated that malaria was excluded, but, on the other hand, interpretation of the Act has been rather different. As a matter of fact, during the war (in 1916) sufferers from malaria received compensation if they had been working in the military zones, and Appeal Court decisions awarded compensation for malaria as an accident even if it had been the indirect cause of the death of the workman.

Discussion mainly centres around the question of whether the inoculation point for the disease is "sudden" and "occurs in the course of employment". The question has been raised whether several inoculations are necessary. It is admitted that a single inoculation may be sufficient to cause the disease and that the number of inoculated parasites does not affect the question, or the duration of incubation and the severity of the infection.

Evidently the bite, as the primary cause of the malarial infection, can always be considered as single.
As has been said elsewhere (see article "Occupational Diseases: Definition and Compensation"), infective agents do not act quantitatively, but qualitatively.

The opponents of compensation take the view, on the contrary, that the risk of inoculation exists in every malarial area and that consequently the element of something "abnormal," "unexpected," and "sudden" which characterises an accident does not exist. The difficulty of defining the moment of inoculation and consequent proof that it has occurred "in the course of employment" is also present. While it is true that the risk is bound up with the environment, the limits are too indefinite to be able to admit this risk.

Those advocating claims reply that the risk is indirect, extending over all workers, but especially present in a greater degree for certain classes called on to live and to carry out their work in a malarial region. Discussion arises more in regard to the degree of the risk rather than to its existence. Certain authorities consider that it would suffice to prove that in the course of work the morbid phenomena are strictly connected with the work done, in order to justify the right to compensation.

The Arbitration Commission (Italy, 1930) was of opinion that in cases of malaria it was not possible to say whether the disease was contracted during work or under other conditions. Proof of specific risk was therefore lacking. The Commission pointed out that it has occurred "in the course of employment" is also present. Malaria cannot then be covered by the Accident Compensation Act.

The Central Commission has felt it its duty to resume the study of this question and to support a decision on the above lines.

Ranelletti (1930), who has in his turn examined the different points under discussion, considers that it is an industrial disease rather than an accident, because, he says, the legislature has from the first taken the view that the law on compensation for accidents during employment does not cover "malarial" risks: the element of a "violent cause" is lacking and while amongst some classes of workers it is possible to prove that it occurs "in the course of employment", it is a question in their case of an industrial disease and not an accident.

A Bill, which has not yet become law, was introduced in November 1930, interpreting section 7 of the Act of 31 January 1904, and section 3 of the Decree of 23 August 1917, which states that malaria is not included among accidents caused by violence in the course of work as envisaged by these sections.

Malaria is compulsorily notifiable as an industrial disease in the State of Illinois: Compensation is awarded in Brazil when it affects agricultural labourers.

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Manganese


Manganese (symbol Mn) is a grey, hard, brittle metallic element, fusible with difficulty, which is found in various minerals: pyrolusite, managanite or acedese, warvicite, palomelane, braunite, hausmannite, etc. The mineral most used, however, is pyrolusite (manganese peroxide or dioxide), of which the ores contain 30 to 90 per cent.

Pure metallic manganese is obtained to-day by aluminothermy, according to the Goldschmidt process, starting with the calcining of the pyrolusite. It is also prepared by reduction of the oxides of manganese in the electric furnace in the presence of coal.

Manganese is relatively very little used. Its use is mainly in siderurgy as a de-oxidising and desulphurising agent and in the preparation of manganese steel.

The dioxide is the starting point in the manufacture of all manganese preparations. It is much used in the manufacture of accumulators, in the glass industry (decolorising agent), in pottery (as a colouring agent of the glaze), in soap, colours, etc. In chemistry it serves in the manufacture of chlorine or chloride of manganese, obtained as a secondary by-product, which is utilised to generate the dioxide which re-enters again into the cycle. The transformation of the chloride into oxygen compounds of manganese used to be carried out by the Weldon process in order to obtain the regenerated or artificial dioxide.

TOXIC ACTION

Manganese-bearing minerals have caused more symptoms of poisoning
among the workers who handle them than is imagined. Certain persons, it is thought, have a natural resistance to this kind of poisoning, this being assumed from the number of workers who have handled it for years in manganese factories without showing any symptoms.

In 1837 Couper reported the first case of chronic poisoning by manganese dioxide in a worker who was engaged in crushing the mineral; von Jaksch (1901) described three cases amongst workers similarly employed, and Embden (1901) published reports on several cases of the same kind, and these were followed by observations from Friedel (1902), Seiffer (1904) and von Jaksch (1907). In 1913 Seelert collected fifteen cases described by different writers and observers in Europe and at the same time Casamajor reported nine cases which occurred in the United States.

In 1919 Edsall, Drinker and Wilbur gave detailed information regarding three of thirty-nine cases which they had examined. In 1920-1922 the German inspectors of factories described in their reports three cases of neuritis which they ascribed to manganese poisoning. In 1921 Davis and Huey described two cases of poisoning among workmen in an iron and steel works where manganese steel was made; 38.6 per cent. of manganese was found in the coarse dust from the electrical furnace and 18.72 per cent. in the fumes. In 1922 Embden described a fresh case affecting a worker employed in crushing the ore, and the German factory inspectors in their reports for 1923-1926 reported three more cases from manganese mills.

Finally, in 1929 Hilpert read a paper to a medical society on a case which he had studied in 1909.

In Great Britain the first cases of manganese poisoning were described by J. R. Charles in 1922. They referred to three workmen employed in crushing pyrolusite, who presented nervous symptoms. A fourth case was observed by Bridge in a factory where crushing, sieving and packing the washed manganese ore was carried on. Of the three cases described by Charles, one proved fatal and at the autopsy degeneration of the longitudinal fibres of the pons was found. Bridge found that the workers in the factory had been exposed to much fine dust.

Experimental researches undertaken by Handowsky, Schulz and Staemmier bear upon the symptoms of chronic poisoning; those of Lewy and Tiefenbach (1922) on cerebral lesions. Grunstein and Popowa (1929) were able to induce by way of the gastric system degeneration of the nerve cells (brain substance), which was most marked in the corpus striatum and especially in the caudate and lenticular nucleus.

In the monkey, poisoning by manganese salts causes a clinical picture like that produced by lesions of the basal nucleus. Histological examination has shown particularly marked changes in the corpus striatum and globus pallidus of the lenticular nucleus.

According to Schwarz and Pajels (1923) natural pyrolusite provokes in animals an increase during the first months, and a diminution on the other hand in the later months, of the haemoglobin and of the number of red blood cells. So far as relates to toxicity Merck's manganese dioxide appears to be more poisonous than the pyrolusite; on the other hand, the pentoxide and the sesquioxide seem to possess the same toxicity and set up in the course of their administration a marked anaemia. Examination of the blood would thus have a diagnostic value enabling early cases to be brought to light by the anaemia indicating this type of poisoning.

**Sources of Danger**

Besides the toxic action of the mineral, the workmen in manganese mines are naturally exposed to the general risks of such work. Thus, according to the researches of Chmaladze (1928) in the mines of Tschiaturi (Georgia), the conditions of work leave much to be desired, the temperature varying between 12.2° and 18.2° C., and the relative humidity between 19 and 100 per cent. But the most important factor is the insufficiency of fresh air entering (defective movement of air in the shafts). The wetness of the mineral prevents the raising of great quantities of dust, of which the amount varies between 16 and 30 mg. per cubic metre. The conditions of work of those engaged in washing the mineral affects health adversely, as the work is effected in places where the temperature is below that of the outside atmosphere and the relative humidity very high; hence frequent illness from cold occurs.

The work of crushing, sieving, etc., exposes the worker to inhalation of dust, and danger from manganese fumes is present during furnace work. Baader and Mosheim (1932) have both published reports containing particulars of cases of poisoning by man-
ganese which occurred in the manufac-

**Pathology**

The symptoms of the first case observed by Couper consisted of a paralysis, progressively affecting the lower limbs in walking, accompanied by a certain "paresis" of the arms and difficulty in speech. The clinical picture was completed by excessive salivation, but there were no symptoms affecting sensation or tremor, colic or digestive trouble. Comparative analysis of this case of intoxication provides a clinical picture typical of the majority of the cases commencing with difficulty in walking. This is spastic, characterised by rest-

ing the metatarsophalangeal joint against the sole of the foot ("stepping gait") (Hahnertritt) — von Jaksch symp-toms. Nervous symptoms show them-selves regularly, with weakness and

fatigue, a tendency to falling for-

wards when rising and of leaning for-

wards when walking; further, spas-

modic laughter and weeping, paraes-

thesia and tremor of the hands. The

voice becomes monotonous and there

is rigidity in movement with loss of the fine movements of the hands. Finally, an increase in the depth of the respirations has been observed.

Abnormal emotional mental symp-

toms have been reported; the mind is

only rarely affected. Irritability and

the onset of emotional disturbances

and persecution mania have been noted.

Objective examination brings out
difficulty in walking, exaggeration of

the tendon reflexes and of the muscular

tonus, combined with a stolid face and a monotonous voice. In no case has the Babinsky plantar reflex or sensory trouble been found, nor has atrophy been seen. The pupils are not altered in size nor in their reactions; the visual field is normal, although ex-

amination of the fundus of the eye often shows retinal anaemia or con-

gestion.

The cranial nerves have never been found to be affected except in the case of those of the face, affected by paresis causing loss of saliva. As cer-

tain sufferers complain of paraesthesia, lesions of the nerves have been sug-

gested. However, exaggeration of the tendon reflexes and the absence of objective sensory troubles or a mus-

cular atrophy are arguments against any alteration of the peripheral nerves.

Examination of the cerebro-spinal fluid yielded normal reactions without a trace of manganese. Salts of manganese have been found in the bile (Wichert and Harnack) and a small quantity in the intestine and in the urine.

The exact pathology of manganese poisoning has not yet been established with
certainty. The analogy between the clinical picture of this form of poiso-

ning and Parkinsonism on the one hand and the Wilsonian syndrome on

the other makes one suspect analogous cerebral lesions. This has been con-

firmed by the observations of Rohuro Ashizawa (1929) in regard to a chronic case of manganese poisoning which was followed by a post-mortem ex-

amination. It was that of a man of thirty-three years employed in crush-

ing the ore. Six months after com-

mencing work he fell ill, with symp-

toms recalling those of lesions of the corpora striata: hypertension, mask-

like features, tendency to fall back-

wards, objective speech, sardonic laugh-

ner. The malady ended by reaching the pyramidal tracts (exaggerated patellar reflexes). In 1923 poisoning became complicated with tuberculosis and death followed in 1924. Micro-

scopic examination showed degener-

ative lesions of the nerve cells and particularly in the globus pallidus, the lenticular nucleus and the caudate nucleus.

The lesions were less important in the brain, the thalamic region, the corpora quadrigemina and the medulla oblongata.

The fairly extensive lesions found in the liver tissue (Embden) make still closer the connection between poi-

soning by manganese and the Wil-

sonian syndrome.

Attention has been drawn elsewhere to the fact that very often, when a case of progressive lenticular degeneration is found, enquiry brings out the fact that work with manganese was as-

sociated with it.

The disease proceeds progressively when absorption of the poison is con-

tinuous. When absorption ceases, the symptoms after having reached their maximum remain stationary for a more or less lengthy period and then tend to diminish gradually. Thus re-

covery has been described in two fur-

ther cases reported by Charles as re-

sulting from cessation of work. Never-

theless, if the intoxication lasts for a sufficiently long time, a definite lesion results which involves permanent in-

capacity for work.

Attention should also be directed to the observations of von Jaksch as to the occurrence of a true "mangano-

phobia" among workers with man-

ganese. A morbid apprehension leads to the same clinical picture as intoxica-
tion from manganese, but is differentiated from it by the fact that it is of functional origin: very marked diminution of the visual field for white and red and disappearance of the phenomena as a result of adequate treatment (high frequency current). The presence of manganese in the urine was not found.

HYGIENE

The prevention of poisoning by manganese is relatively simple and can be effected by the wearing of a respiratory mask at all times in the presence of dust or vapour, protection against the dust (working clothes and gloves) of the parts of the skin exposed to its influence, since the occurrence of skin absorption is a recognised fact; personal hygiene on the part of the worker. Local exhaust ventilation should be applied at the furnaces to remove fumes and likewise for removal of the dust given off in crushing, sieving, etc. This measure is attended with the best results, for it was found, when applied in one particular factory, that it removed all risk of poisoning encountered by the workers over a period of five or six years.

LEGISLATION

Injury due to manganese is included in the Workmen's Compensation Acts of Chile, Germany, Great Britain, Switzerland, the State of Ohio (poisoning by manganese dioxide), Switzerland (poisoning by manganese peroxide) and the U.S.S.R. (under the general head of industrial poisonings).

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Matches (Lucifer)


HISTORICAL

Matches were invented by Chancel of Briançon. According to Littré they date back to the fourteenth century; Villon (fifteenth century) refers to them in his will. Whether that be so or not, the heads of the matches invented by Chancel were prepared with sulphur and chlorate of potash, and they did not light until they were immersed in sulphuric acid. In 1830, "strike-anywhere" matches (which the Germans attribute to Kammerer, the French to Saunier, and the English to Walker) made their appearance. The sulphur in these matches was covered over
with chlorate of potash, antimony sulphide, and gum; they lighted by friction on glass paper. They were soon improved by replacing the antimony sulphide by phosphorus, which enabled them to ignite more readily. In order to avoid the danger from the use of chlorate of potash, which produced a little explosion at the moment of ignition, Trevani, of Vienna, in 1835, used as an oxidising agent a mixture of red lead and peroxide of manganese, and Preschel, in 1837, peroxide of lead and a mixture of red lead and saltpetre. In 1844, 1860, discovered phosphorus; in 1847, Schröter, of Vienna, suggested replacing the white phosphorus by the red as being non-toxic, less inflammable, inodorous, and more resistant to moisture.

In 1852 Bottcher prepared safety matches without phosphorus which ignited by friction on a surface containing 50 per cent. of red phosphorus.

In 1857 Canouil similarly suggested non-phosphorus matches prepared with dextrine, chlorate of potash, peroxide of lead, pyrites, iron or sulphide of antimony, and a colouring substance. He was followed by Ghigliano, Kummer and Gunther, Jetter, Wiedeshold, Craveri, and others, but without appreciable results. Towards the end of the nineteenth century the French monopoly adopted a paste of Sévene and Cahen composed of 90 parts of sesquisulphide of phosphorus, 200 parts of chlorate of potash, 110 of peroxide of iron, 60 of oxide of zinc, 140 of pulversed glass, 100 of glue, and 290 of water. But the sesquisulphide, proposed by Puscher in 1860, discovered possessing certain advantages, had the disadvantage of containing impurities. At the same time the brothers Purgotti, of Périgueux, placed on the market safety matches of red phosphorus which have been definitely adopted by the industry.

The manufacture of matches is the industry presenting the greatest danger of industrial phosphorus poisoning. It thrives chiefly in Russia, Japan, Norway, Sweden, Finland, Poland, and in Italy.

Manufacture

(a) Making the splints.—The manufacture of matches comprises that of the splints, the heads, and of the boxes. The splints can be either of wood or wax. For wooden splints Russian aspen has generally been used, sometimes poplar (Belgium, Italy) or pine (for sulphur matches: Switzerland).

The wood is cross sawn either by hand or the machine into blocks of a certain length which are then divided into strips and these again into uniform splints, each of about 2 mm. in thickness. The rods are then divided into little pieces of the length of matches. They are inserted in an iron frame, and dried in a room heated by steam. In some workrooms forced drying is used; the splints are laid on hurdles or drawers which are introduced into a closed box through which hot air is drawn by a fan. When completely dry they are placed in a revolving drum where they acquire a certain lustre from friction with a little paraffin.

The sorting or straightening of the splints is done on a table slightly inclined and divided into a series of longitudinal channels. The bottom of this table is latticed and pierced crosswise by a series of slits the size of which is equal to half the length of a match, thus allowing the unduly short splints to pass through these slits.

(b) Impregnating.—The splints are next dressed. Safety matches are impregnated before drying, that is, are dipped in a bath of phosphoric acid and ammonium phosphate often containing, in addition, some colouring substance. The process is carried out in a barrel or a vat of cemented masonry. Its object is to prevent the matches from showing any point of ignition as soon as the flame is extinguished.

Preparation of the paste for the heads is done in a separate workroom. The ingredients are mixed cold, except when the composition contains phosphorus, in which case the vat is heated to liquefy the mass. Above the vat is a hood with exhaust draught to carry away the poisonous fumes. This process can be done in special apparatus, hermetically closed and kept in a bain-marie. A duct carries the fumes into a chimney.

The substance composing the paste varies in different factories. For ordinary matches, formerly, white phosphorus, sulphate of lead, powdered glass, and glue were used. In addition, they may be dipped in a sulphur bath.

In England the paste used consisted of white phosphorus (60 per cent.) mixed with an aqueous solution of glue, powdered glass, and an oxidising solution: chlorate of potash and zinc white with chalk or kieselguhr or peroxide of lead, red lead, and a colouring substance (aniline, fuchsine, lamp black). A paraffin bath followed.

For safety matches use was made of the following: flowers of sulphur, chlorate of potash, zinc white, ochre, powdered glass, glue, gum arabic and colophony.

At the present time matches are used made of sesquisulphide of phosphorus, the paste for which consists of sesquisulphide of phosphorus, chlorate of potash, zinc oxide, red ochre, powdered glass, strong glue, and water.

The application of the paste to the splints is done by machinery. This process can be carried out in two ways: in the "Seebold" method the splints are arranged in parallel lines by means of
a mechanical device, and are then introduced into frames which keep them in position. In the "Lagneau" method the sticks are introduced into the frames anyhow without preliminary arrangement. The frame is formed of a perforated plate with holes into which the splints fit. It must be kept in a vertical position to prevent the splints falling out.

In order to make the head, one extremity of the splint is dipped into a bath of sulphur or paraffin and then into the phosphorus paste. At the present time the bath which obliged the workman to plunge his hands into the phosphorus paste is no longer used; the frames are dipped vertically into the first bath of sulphur and paraffin (kept melted by the heat from a burner, or by a coil of pipes through which steam is passed) and then into the inflammable paste which is spread out in a thin layer on a table. The paraffined matches have the whole splint impregnated. In well-managed factories each table is provided with a hood for removing fumes. Obviously, however, the operation is much less dangerous when dipping is done mechanically and the paraffining by steam.

(c) Drying.— After having been soaked in paraffin or sulphur and then dipped in phosphorus paste the matches must be dried before they are boxed. The drying is done in stoves, generally heated by steam. Each match contains on an average 3-5 mg. of phosphorus on heating by steam.

(d) Boxing.— Match boxes can either be of cardboard or wood. The former are only used for phosphorus matches and are made either in the factory (by machinery) or as a home industry. They are made from a single piece of cardboard; the different operations reduce themselves to folding the edges and application of the starch paste. Wooden boxes are habitually used for safety matches. The manufacture of these boxes comprises two series of operations: the preparation of the veneers of wood, then the fashioning of the boxes, done by hand or by machinery, the whole followed by drying in a cabinet through which passes a current of hot air, and into which the boxes pass one after the other on an endless band.

Filling the boxes is done either by hand or by machinery. Application of the rubbing strip made of powdered glass or iron fillings fixed with glue is done last in order to reduce to a minimum the risk of explosion or spontaneous firing of the contents. The rubbing surface in English matches consists simply of a layer of glue on to which sand or powdered glass is applied.

The boxes are, lastly, made up into packages. The frictional surface of safety matches is an inflammable composition containing red phosphorus mixed with powdered glass, manganese dioxide, or sulphate of antimony.

Probably 90 per cent. of the matches made to-day in Great Britain, America, Sweden, and some other countries are made in remarkable continuous machines, in which practically blocks of wood entered at one end pass through all the processes of impregnating, dipping, drying, and boxing mechanically, except for the final regulation of the number of matches per box.

Logs of wood are placed on a peeling or veneering machine, by which long thin veneers of wood are peeled off. These veneers—the thickness of a match—are piled on top of one another and fed into machines containing a guillotine and subsidiary smaller knives, which cut the veneer into match lengths. One such machine will make 56,000 splints a minute.

The match splints are boiled for five minutes in the impregnating solution and subsequently, for the next two hours, are rolled round and round drums for polishing and drying purposes. They then pass through screens to collect the matches so that they lie the same way, and they are fixed in slowly moving flexible metal bands. The serpentine coil of plain splints carries the matches through a bath of paraffin wax, then over a roller covered with the igniting composition of sesquioxide, etc., and after that they travel up and down the serpentine coils over heated drums, while fans assist the drying by the extraction of air.

Finally the matches drop automatically into steel slots the size of the match boxes and the boxes are brought opposite to these slots and filled. It is only at this point that hand work comes in, to prevent unduly tight packing and to detect any irregularity, or any imperfect boxes.

(e) Special kinds of matches.— Some kinds of matches differ from safety in certain particulars. Thus, for example, "repsticker" matches are matches of a new type, of which the head is prepared not only with the mixture of substances entering into the composition of the heads of safety matches, but also containing other substances used to form the frictional surface. This paste contains red phosphorus which
MATCHES (LUCIFER)

explains why it will strike on any slightly roughened surface.

Paraffining is done after the head is made so that the inflammable material is protected by an impermeable coat. The "reptstickor" matches are consequently less affected by moisture than ordinary safety matches.

Wax matches differ from the ordinary "strike anywhere" matches in that the splint is made up of cotton threads saturated in, and enveloped with, wax. Their manufacture comprises two series of operations; first the spinning of the thread, next cutting to length, sorting, pressing, trimming and mounting. Dipping and drying are done in the same way as with wooden matches except that the head and rubbing surface is rather different. In these the splint portion is generally white and the head red.

**DANGER**

At all stages of the operations involving contact with phosphorus, the workman is exposed to phosphorus fumes, and to the white fumes of which the acid and piquant smell is due to the formation of nitrate of phosphorus, which, in combination with oxygen, forms hypophosphorous, phosphorous, phosphoric, and phosphatic acids. According to Thorpe, these products are present in the following proportions: 20-25 per cent. phosphorus, 10 per cent. phosphoric acid, and 70-78 per cent. phosphatic acid.

Thorpe found the following results on analysis of the air in a lucifer match factory in London: In the largest workrooms, ventilated by open windows, there were present, at a point 35-40 cm. above the liquid phosphorus mass, 0.00002 grm. of free phosphorus or of the oxide per 100 litres of air; and in the small and less well ventilated rooms, where boxing was done, 0.00012 grm., as well as noticeable quantities of visible fumes produced whenever the matches fired accidentally in boxing — a very frequent occurrence. Calculating that on the average 1,800 respiratory movements are made per hour, the quantity of phosphorus inhaled can be estimated at 1 mg. in the rooms where mixing of the paste is carried on, and 6 mg. in the boxing rooms.

This same expert found that 22 workmen, after working four hours, showed on their hands about 1.7 grm. of phosphorus, and the water in which these workers washed their hands contained 0.0373 grm., although they had washed with soap and a nail brush before commencing work.

The specially dangerous processes are the preparation of the paste, dipping, drying, and filling the boxes. When white phosphorus was used, Teyxeira estimated that 60 per cent. of the workers in match factories were affected by it.

Use of the sesquisulphide can also set up lesions of an eczematous character. Legge, in 1906, reported the occurrence of such an outbreak on the skin of some dippers, but not those employed in the mixing. In 1920 he described cases of conjunctivitis and was of opinion this was due to hydrogen sulphide given off in the process.

Paraffin can also set up eczema (especially on the hands) in the women engaged in boxing.

In addition to the effects peculiar to phosphorus poisoning (see article "Phosphorus") other fairly characteristic eczematous lesions are met with among match makers. Burns (of the first, second, and third degrees) are especially common among those releasing the matches from the frames prior to boxing. They are localised on the palm of the right hand, especially about the hypothenar eminence, and the first phalanx of the ring and little fingers. The character of these burns varies, however, with the kind of paste used. They are very painful with paste containing chlorate, but in this case the burn is relatively limited and heals fairly rapidly. On the other hand, if the paste contains red lead, the lesion is very painful, widespread, and heals more slowly.

Mention should be made of the danger from lead compounds, chrome, etc. used in making the paste, but which are not known to have caused serious damage except in the case of chrome compounds — ulceration of the skin and perforation of the septum of the nose (Moritz and Röpke, etc.).

In some Swedish safety match factories chrome salts are used to the extent of 3-4 per cent. in the paste (about half a milligram per match head). Wodt has reported 84 cases of chrome ulceration, some severe, either on the fingers or nasal mucous membrane, with perforation of the septum. Lastly, the manufacture of Danish matches has caused localised skin irritation on the hands of dippers, etc. Rasch in his opinion (1918) that 6 to 7 cases coming to his knowledge were due to traces of white phosphorus on the rubbing surface which had been carried by the fingers to different parts of the body.

Machinery has led to the disappearance of traces of certain lesions—teno-synovitis and whitlow—described by Arnaud, which formerly troubled the persons making the sticks.
A vicious position of the fingers (especially of the little finger) has been observed among the boxers, more commonly when they are young persons, in applying the metal stick for opening and gumming on the labels, etc. They do the various operations with the thumb and index finger, keeping the others in a position of forced flexion. This position induces a permanent spasm of certain groups of muscles or a contraction of the palmar fascia due to small multiple and repeated injuries, or to synovitis of the permanent spasm of certain groups of tendons of the flexor muscles of the fingers due to the same slight localised multiple and repeated injuries.

**STATISTICS**

The first case of phosphorus necrosis in a match worker — Moritz — was described in 1845 by Lorinzer. The data do not enable one to follow the extension of this malady in the early years after the industry was established.

In Germany 49 cases were reported in 1847. Moritz and Röpke, in a report in 1901 dealing with 64 workers in a match factory at Hitdorf (Solingen), reported 14 cases of pyorrhoea alveolaris, and 19 of ulceration of the septum with perforation in two cases. The first case of phosphorus necrosis reported was in 1896, and in the period 1896-1902 on 48 in the clinic at Neustadt-Jena. Hölze in 1905 cited 947 known cases of phosphorus necrosis in Europe, but recognised that his figures were not complete.

In Austria between 1866 and 1875 the hospitals of Vienna treated 126 cases. For the period 1896 to 1905 the cases numbered 350 to 400.

In Belgium, for the years 1904, 1906, 1908, and 1910, not more than one case was reported yearly, but the medical inspectors, taking account only of these persons 65 per cent, were exposed under the age of 16 (121 boys and 195 girls). Of these persons 65 per cent. were exposed to the risk of phosphorus poisoning — women and children to a greater extent than the men. The Report describes more than 150 cases, with 4 deaths.

In Great Britain, according to the Annual Report of the Chief Inspector of Factories for 1899 (p. 318), the total cases of phosphorus necrosis in the match industry in the previous 20 years (including cases also in the manufacture of phosphorus) of which there was definite record numbered 102. Prior to 1896 there were 92 cases; in 1898, six; and in 1899, four. Three other cases were reported in 1899, but they did not reach the stage of necrosis and were included among the suspected cases. Nineteen of the 102 cases were fatal.

Between 1900 and 1904 there were 9 cases (3 fatal), and between 1905 and 1908 8 cases (2 fatal). Subsequently no further case has been reported in match factories. This happy result in British factories was largely due to willingness on the part of the holders of the patent rights of the non-phosphorous paste to allow other manufacturers to use it.

In Italy, 100 cases occurred between 1877 and 1913, but the wide development of match making as a home industry makes it probable that this figure ought to be higher owing to unrecognised cases.

The monograph of Vallavatta, published in 1914, states that 5 cases of necrosis were treated in 1912-1913 in the Industrial Diseases Clinic of Milan, and gives a list of 58 cases for the period 1874 to 1905, for which had not been published hitherto. Of these, 6 had occurred in the match factories of Lombardy, 18 in those of Piedmont, 9 in those of Tuscany, while 21 had been reported between 1904 and 1913 in the factories of Rome and Venice.

The morbidity percentage for Italy for some years before 1913 was about 1.4, while statistics from other countries before the abolition of the use of white phosphorus show, for Great Britain 1 per cent., for Switzerland 1.6—3 per cent, and for France 2.3 per cent. These percentages are reckoned on the number of cases and the number of workpeople, but without regard to the fact that quite half of the latter are not in contact with the toxic agent even in the most dangerous factories.

A more methodical enquiry carried out in an Italian factory, taking account only of the workers exposed to danger, gave 2.76 per cent. of cases of phosphorism,
distributed according to the different departments, with a maximum of 10 to 12 per cent. for the workers employed in mixing the paste. Introduction of machinery has certainly improved the hygienic conditions, but in spite of that phosphorus necrosis seems still to be pretty frequent, as in the space of two years 11 cases were treated by the Industrial Diseases Clinic of Milan. Between 1914 and 1918, 12 cases (with 1 death) were reported in a single factory.

In Norway, since 1913, when the law prohibiting the importation, manufacture, and sale of matches made with white phosphorus came into force, no case of phosphorus poisoning has been reported. (See also article "Explosives": Fireworks.)

**Hygiene**

The main safeguard is careful examination of persons seeking employment and rejection of those with defective teeth. At the same time periodic medical examination must be arranged for, so as to detect at an early stage dental defects. Should a workman have undergone dental treatment for an extraction he should not be allowed to be re-employed until the wound has completely healed. The dental examination should be in the hands naturally of a dentist, but even this measure does not suffice to guard against all danger of phosphorus poisoning.

As regards the hygiene of the different processes, these should be conducted as far as possible in well-ventilated workrooms: each process in a separate room, and the walls and floor should be carefully and regularly cleaned. Of first importance is locally applied exhaust ventilation as near as possible to the point of generation to remove the fumes to the outer air. The fumes have a tendency to spread from their point of origin, and if the hood is placed too high the atmosphere of the workroom is vitiated. A case in point illustrating this was an Italian factory where cases had been very few, yet on installation of a bad system of exhaust ventilation, which dispersed rather than extracted the fumes, 5 cases of phosphorus poisoning occurred.

Mixing the paste should be done in iron receptacles capable of being tightly closed.

The dipping table should be provided with a series of exhaust hoods situated at its posterior end so as to draw the fumes away from the worker. Further, a powerful fan should be placed in the roof of the room where paraffining is done.

Good ventilation should be provided for the trimming and drying rooms, and entry into these should not be allowed until this has been carried out. Through ventilation should be kept up in the drying stoves so long as the workers have to enter them, and a thermometer should be hung in these stoves which should not show a higher reading than 35° C. Hands labour here should be replaced by mechanical means rendering entry into the stoves unnecessary.

Packing should be done in large well-ventilated rooms separate from the other workrooms. The windows should be provided with metallic screens of very fine mesh.

The quantity of raw materials in hand should be limited and waste (shavings and everything likely to cause risk of fire, etc.) removed every day. All suitable precautions must be taken against fire (in construction and installations, etc.). Special precautions should be taken to protect the workers engaged in mixing (danger of load, red lead, nitric and chlorate of potassium). Working hours should be limited and workmen instructed as to the professional risk they run.

In Germany the following measures have been suggested since 1884: prohibition of work with phosphorus paste; exclusion of women, young persons, and children from the following processes: dipping, drying, boxing, and preliminary packing; limitation of the hours of work; complete separation of the rooms in which the most dangerous processes are carried on; special installations of ventilating fans, etc., for preventing toxic fumes entering the workrooms; rooms of sufficient size for ample cubic space and a sufficient volume of air per person so as to reduce the proportion of fume as much as possible; good mechanical ventilation; maximum temperature of 38° C. in the drying stoves in order to avoid excessive evaporation of phosphorus; daily cleaning of the floors, machines, and trimming rooms; repainting of the walls every six months; provision of overalls, and of separate cloak rooms and of washing accommodation for the face and hands; evaporation of turpentine vapour in rooms where much phosphorus fumes are given off; compulsory cleaning of the teeth with a dentifrice or permanganate of potassium at the cost of the employer; submission of plans of new and of alterations in existing, factories to the Factory Department; medical examination before taking up employment and at periodic intervals with exclusion of all persons suffering from dental caries and phosphorus poisoning, etc.
LEGISLATION

Whether the preventive measures had not been constantly enforced or whether they had not been adequate, it is clear that no sensible diminution in cases had been achieved up to the time when a beginning was made with the prohibition of the use of white phosphorus, although technical progress allowed the carrying out automatically of almost all the processes.

The first country to pass a law prohibiting the use of white phosphorus in the manufacture of matches was Finland in 1874, followed in 1879 by Denmark. For four years no case of phosphorus poisoning has been reported in these two countries. Switzerland prohibited, provisionally in 1879 and definitely in 1898, the use of white phosphorus. In 1901 the Netherlands followed suit.

In Germany a motion presented to the Reichstag on 27 June 1879 demanded the prohibition of white phosphorus in the match industry, but a Committee of Enquiry contented itself with the recommendation of Regulations, although acknowledging that prohibition was the simplest and most effective solution. The law of 10 May 1903, however, prohibited, as from 1907, the use of white phosphorus in the manufacture of matches as well as their importation and sale. As the prohibition hampered exportation — the very high price of red phosphorus placed the countries using it in a position of inferiority in international markets — a Convention (Berne, Convention of 26 September 1906) was signed by France, Germany, Italy, Luxemburg, the Netherlands and Switzerland to prohibit on their territories the importation and exportation of such phosphorus. Some delay in the execution of the agreement, however, was recognised as necessary for the industry to adapt itself to the changed conditions and the alterations in the cost of production. This was fixed at three years for the countries signing the Convention and at five for those which might subsequently signify their adhesion to the Convention. Poland (14 January 1921) and China (6 December 1923) have thus subscribed.

The following States have since then signed their adhesion to the Berne Convention: Austria in 1909, Great Britain, New Zealand and New South Wales in 1910, Hungary in 1911, Mexico in 1912, Canada in 1914, Japan in 1921 (to come into force in 1922), Belgium, Bulgaria, Estonia, Finland, India, Irish Free State, Palestine, Rumania, South Africa, Spain and Sweden.

The United States, by a law in 1912 (enforced in July 1913), imposed a tax on white phosphorus matches, and since 1 January 1913 and 1914 prohibited interstate importation and exportation of such matches.

It is worth noting that, as no industrial disease resulted from the use of sesquiphosphide of phosphorus, Switzerland, after 30 years' experience, abrogated the provisions of the law requiring special measures for the workers such as preliminary medical and subsequent periodic examination.

Young persons were prohibited from dipping, drying, and packing under a certain age, which differed in the regulations of different countries. This exclusion, however, has become purposeless in view of the prohibition of white phosphorus.

Regulations relative to match factories were issued in Finland (1924) and in Portugal (1926).

As regards notification of and compensation for necrosis see the article "Phosphorus".

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Mechanical Engineering and Metal Work


Under this title have been grouped all industrial operations following metallurgical extraction and serving to transform the products furnished thereby into finished objects adapted to the multiple needs of industrial or social activities.

Mechanical engineering comprises roughly all static constructions, i.e. all metallic parts for the building trade and public works intended to constitute fixtures (bridges, frame-works, etc.), mechanical apparatus for general application and characterised by the fact that in contrast to the above they constitute essential parts of moving machinery (motors, haulage apparatus, etc.), mechanical material and machine tools varying infinitely in accordance with the material manipulated and the products to be obtained, the construction of transport material (land, sea and air), and operations of maintenance, repair and demolition (breaking up of ships, for instance), which constitute in themselves highly specialised industries. Along with mechanical engineering may be considered a certain number of other industries. For instance, the large-scale and small ironmongery trades (manufacture of various instruments midway between large forged articles and small objects made by wheelwrights; utensils of medium and small dimensions, principally household goods), ironwork; edged tools, tinsmiths' goods, and certain special types of manufacture, such as the manufacture of arms, for instance.
The raw materials are many and varied in form, and are generally delivered in their crude state by metallurgical factories.

The following metals are used: iron, steel, cast iron or steel in the crude state or moulded, copper, zinc, lead, aluminium, brass, bronze, various alloys, etc.; numerous products of mineral, vegetable or animal origin, serving especially as accessory material (flint, grindstones, wood, cardboard, paper, leather, animal hair, etc.); various products such as rubber, vulcanised fibre; colours and varnishing materials (as means of protection of the metal against external agents and for imparting to the finished objects a more agreeable aspect and facilitating their maintenance); red lead or minium; iron oxide: oil colours, varnishes, enamels, etc.

The principal operations may be summarised as follows:

**Shaping** (subsequent to foundry work and circular brushing or allied processes; stamping, sheathing with metal, rolling, wire-drawing, drawing, plate-bending, cutting-out, etc.); rough shaping; work on machine tools; effects this operation by means of processes formerly done by hand by means of machines which are partly or totally automatic: lathes, boring, drilling, threading, screw-cutting and grooving machines. The articles are then adjusted, fitted and inspected. During this phase of production the articles in question are sometimes subjected to operations which modify their hardness or malleability: tempering (by water, oil, molten lead, cyanides, etc.), followed by annealing.

**Finishing** comprises a series of operations amongst which are included scouring and other chemical (cold bath) or mechanical (sand spray) — grinding and polishing, sharpening, etc. Scouring with a sand spray is becoming more and more widely utilised in foundries as well as for metallic objects prior to enamelling; nickel-plating and hard soldering, etc. For this operation there is used a spray consisting of a fluid (air, steam or water) projected under pressure and at great speed against the surface to be treated and carrying with it a mass of sand or other substance having similar properties (carbon-bondum, lead shot, etc.). The pressures and the products utilised vary in accordance with the technical needs, and may be applied by means of a free spray, generally under a hood, or in special apparatus or in chambers provided for the purpose, or by means of a spray which is completely enclosed.

**Polishing** of objects is effected by files or brushes on a polishing lathe, by a wooden grindstone covered with buffalio leather, and by the application of various products: rouge, pumice, emery, whiting, etc. (see articles “Metal Grinding and Polishing” and “Abrasives”).

**Assembling and fitting** consist in grouping together the different elements for machine construction, and comprise various operations, such as, for example, tightening, cold and hot riveting done by hand or by means of a pneumatic hammer, smoothing, white soldering, autogenous welding, hard soldering, etc.

The fitting of metallic constructions involves the erection of scaffolding, hoisting of parts, fixing and erection properly so-called. Mention should also be made of the work of ship-breaking.

The operations of galvanisation, plating with zinc, lead or nickel, chrome-plating, etc., with a view to covering the metal with a protective coat, are generally effected prior to fitting. The latter operations comprise finishing, scraping, pumicing, painting and varnishing. Many of these operations have been made the subject of special articles.

Apart from the above operations relative to the manufacture of metals in general, mention should here be made of a long series of special industries such as metallic rope works, manufacture of screw nails, bolts, nails and lattice-work, etc.

Finally, the working up of raw materials of all kinds may be remarked, practised in certain cases (manufacture of rolling-stock, for instance). Similarly, there should be included mention of certain work carried out by other occupational grades: wheelwrights, cabinet-makers, harness-makers, etc.

**SOURCES OF RISK**

In view of the numerous and very various operations dealt with in this article, it is obviously difficult to summarise all the possible sources of risk met with during such work. On the other hand, there is a danger of repeating here matter already dealt with in other articles (“Abrasives”, “Metal Grinding and Polishing”, “Copper-Boiler Making”, etc.). For this reason attention will be confined to enumerating the most important causes of danger without attempting to provide a complete list of these.

The material handled may constitute a source of risk by reason of the dust liberated during the numerous operations referred to in preceding paragraphs. These dusts are generally of mixed origin: mineral, animal or vegetable; and may comprise coal, sand, abrasives, metal, as well as dusts of animal or vegetable origin: from the accessory products utilised, such as buffallo leather, cloth, sawdust, etc.

Reference should also be made to the sand projected by the sand spray, since this sand contains silica, calcium carbonate and various impurities (iron, iron oxide, lead, etc.). Thus, for instance, attention has been called to the presence of considerable quantities of lead which have given rise to cases of lead poisoning (J. Werner, 1928). The lead content of the sand was reduced after usage demonstrating the passage of lead in the form of dust: a variety
of sand, the lead content of which was 0.52 per cent., prior to use in the sand blast, only contained 0.34 per cent. of lead after the operation. In all cases sand particles exert a harmful effect on the worker's health by reason of their irritant effect on the respiratory passages.

As regards the effect of pumicing and dry scraping of metallic surfaces painted with lead colours, reference should be made to the investigation conducted by McNair and Price (1927). A true epidemic of serious cases which occurred at Detroit (1921-1924) in the motor industry has been described by Donald and Dean.

The use of certain cements with a minium or white lead basis exposes workers to the lead risk. Thus lead poisoning was notified as occurring amongst riveters engaged on coating the interior of the riveting-hole with minium prior to the introduction of the hot rivet, and amongst workers engaged in the construction of locomotives while effecting the particular operation of levelling the wheels on their axes (use of white lead). Paints for protecting metals, and in particular those for protecting constructional metal work, have a minium basis, especially for the basic coats. At the present time in many cases rapid drying paints are utilised (with a benzol basis), or cold enamels.

Acids are used for cleaning and scouring. Tempering baths have a cyanide basis. For the oiling of machine tools use is made of mineral oils (see articles "Petroleum" and "Fatty Substances"), with a view to preventing heating and seizing of the metal and accelerating expulsion of metal turnings and shavings. In certain work use is made of vegetable or animal oils and very often of an emulsion of fatty substances in an alkaline solution (soap). It is important to recall in this connection that the waste used for cleaning machines until it is completely impregnated with oil or blackened grease, not only favours the harmful action of these products, but further, having undergone neither washing nor disinfection, often represents a means of transmitting various pathogenic microbes (infection of wounds). It should further be recalled that such rags constitute also, in the absence of adequate precautions, a cause of fire.

The use of red hot baths and tempering baths is becoming much more extensive, especially with baths containing a mixture of nitrates of potassium and sodium heated to 500° C. The dangers of explosion and fire have induced the workers to demand an enquiry into the causes of very serious accidents which have occurred on several occasions. It was at first thought that organic material was to blame, then a light metal "electron" inadvertently admitted to the bath. It was, on the other hand, proved that the real cause was water, the accidental penetration of which into the nitrates in a molten state gave rise to explosion. The particles projected, when coming into contact with organic substances, cause instantaneous ignition (Gremp).

Certain operations in which there is exposure to the combined action of dusts and lubricating products are particularly dirty.

Gases, fumes and smoke coming from the hearths of furnaces, as well as from the metal in course of manipulation (melting, forging, welding, etc.), constitute a fairly frequent cause of contamination of the atmosphere. There may be cited as an instance the acid, sulphuric and nitrate fumes liberated during scouring and burnishing, the droplets from the baths, which are thrown off in steam and disseminated in the surrounding atmosphere, the hydrocyanic acid (found to be present in small quantities by Leschtschinskaja, 1927), the carbon dioxide and also monoxide coming from the hearths and from poor gas used for heating, etc. Attention has also been drawn to the possibility of poisoning by arseniuretted hydrogen during scouring of sheet-iron plates by means of sulphuric acid containing traces of arsenical substances (case of Barker in 1864; seven cases in Great Britain in 1902; three cases reported by Gerbis, one of which was fatal, in 1925; one case in the United States in 1928; in regard to which, however, the subsequent enquiry showed doubt as to its professional origin); by lead (Legge), etc.

The manufacture of beryl, a light metal which in small quantities enters into the alloys of other light metals such as aluminium, gives rise during melting to hydro-fluoric acid fumes. These fumes have caused fairly serious injuries amongst workers, and particularly a cutaneous eruption lasting several days. Even certain persons inhabiting the neighbourhood have suffered from illness as a result of the toxic and evil-smelling gases liberated.

There must not be overlooked certain injuries due to the use of polishing, lacquering and painting products used on metals (alcohols, ether, acetone, various solvents) as well as the operations of repairing vats, boilers, cist-
erns, especially when these contain heavy oils, petrol spirit or other toxic products.

The conditions of work may also constitute sources of risk. Where the work is carried out in the open air, there must be taken into account the influence of the inclemency of the weather on the system (damp, great heat, rain, wind). Likewise work undertaken in partially open sheds may involve exposure to heat rays (radiant heat from the ovens, forging of metallic objects at red or white heat) and luminous rays (during welding, for instance), certain of which are very rich in ultra-violet rays. It is also necessary to remember the effect of noise on the hearing and on the nervous system.

There are besides certain operations which, were they not effected by means of mechanical or automatic apparatus, demand a very great expenditure of physical energy, and which are liable to cause strain and exhaustion. On the other hand, whilst many machines economise the physical labour of the worker, they make on him at the same time other heavy demands: rapidity of movement, close attention, dexterity, visual concentration, etc. During other operations work has to be accomplished under special conditions and requires special selection of the workers: for instance in metallic construction of buildings (skyscrapers), in the course of which the worker is obliged to work on a framework and to accomplish at times highly dangerous balancing feats; in marine construction, on scaffolding of temporary construction above the water, or within the holds, etc.; on ship-breaking (danger of lead poisoning).

The working posture peculiar to certain types of work (see article “Metal Grinding and Polishing”) may represent a source of danger when combined with an unduly long working shift, thus favouring the outbreak of phenomena of fatigue and exhaustion. Thus, for instance, there has been reported amongst certain workers obliged to work in a standing position on account of the inclemency of the weather on the system (damp, great heat, rain, wind). Likewise work undertaken in partially open sheds may involve exposure to heat rays (radiant heat from the ovens, forging of metallic objects at red or white heat) and luminous rays (during welding, for instance), certain of which are very rich in ultra-violet rays. It is also necessary to remember the effect of noise on the hearing and on the nervous system.

Apart from certain old statistics prepared by Sommerfeld and Hirt and quoted by Zadek, no important statistical data exists relative to morbidity amongst workers engaged in mechanical engineering and metal work.

Based on an analysis of cards belonging to the Austrian Sickness Funds and relating to metal workers in Vienna, Adler and Herzmark has drawn attention (1921) to the great frequency of tuberculosis amongst these workers, especially amongst young persons — affections of the pulmonary apex, and more particularly still amongst women between twenty and thirty years of age who appear to be much more frequently affected than the male workers. Amongst locksmiths and mechanics the percentage of days of sickness due to tuberculosis diminishes with advancing age.

In Germany amongst workers engaged in a ship-breaking yard (Kiel) Engelsmann found in 1923 that 32 workers out of 39 engaged on cutting sheet iron coated with zinc by blow pipe suffered from affections similar to zinc funder's fever. The action of lead being eliminated, the author ascribed the troubles to absorption of zinc. In another shipyard 22 out of 41 workers showed symptoms of lead poisoning. Analysis of the air gave a lead content of 5.6 mg. per 100 litres of air.

In Great Britain from 1920 to 1927 the medical inspectorate received reports of 265 cases of lead poisoning — 138 cases only in 1924 — one of which was fatal, due to lead fumes volatilised by the action of the oxyacetylene flame used for cutting metal (painted with red lead!): enquiries by Legge, Bridge, etc.

Riveting also involves a risk of lead poisoning. In 1928 Fraenkel recorded a case of poisoning due to a cause so far unknown. The piercing of rivet holes having been effected, minium is introduced into these and heated to 100° C., and the rivet is thereupon hammered with a compressed-air hammer. Under the action of the heat the minium liberates lead fumes.

Finally, there should not be overlooked the risk of accidents due to traumaism, splashing (molten metal, acid or alkaline drops), especially afflicting the hands and eyes, falls of the worker or of objects on to the worker, etc.

### Statistical Data

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In Great Britain Middleton has studied (1923) working conditions and the state of health of workers engaged in metal grinding and removing of sand from castings.
His enquiry, which is very complete, comprises a technical section (analysis of the operations, composition of the grindstones, etc.), a medical part (examination of 1,153 workers), and a third part dealing with hygiene (analysis of air samples, means of protection, etc.). Despite the fact that for some time back the composition of grindstones has been considerably improved, unfavourable working conditions still exist in certain factories, more especially in the town of Sheffield.

Without scrutinising in detail this interesting study, it is sufficient to recall that 4.7 per cent. of the workers examined showed obvious signs of pulmonary tuberculosis, 9.3 per cent. suspected tuberculosis, and 19 per cent. bronchial catarrh.

Analyses of 123 dust samples collected with Owen's konimeter revealed a quantity of dust varying from 496 to 26,377 particles per cubic centimetre of air during wet grinding on grinders made of sandstone and metal polishing.

The proportion of dust particles exceeding two microns in diameter varied between 0.7 and 34 per cent.

In the United States Brown (1926) met with 83 cases of lead poisoning.

In the U.S.S.R. several investigations have been effected in the mechanical engineering industry. A brief reference may be made to that of Marschak (1923) concerning 7,815 workers who showed a number of days' sickness four times as high as that recorded for the year 1914, but half that for 1920, even though the number for 1923 had increased as compared with that for 1922; likewise the enquiry of Gleserow (1928) dealing with cases of ocular traumatism amounting to 5,769 over a period of four and a half years. Occupational traumatism accounted for a fifth of the total. The left eye was most often affected (52.1 per cent.), this being due to the position of the worker's head, which is generally turned to the right. Diminution of natural lighting during autumn and winter were said to explain the increase of accidents met with. Metallic particles and splashings of molten metal most frequently account for these accidents, amongst which serious forms were however rare (0.7 per cent. of the total). Ter Gasaroff, of Baku, in examining (1927) 136 blacksmiths in a large factory, found chronic lesions of the mucous membrane (conjunctivae, upper respiratory passages, emphysema, serious derangement of the circulatory system, and even in certain cases modifications of the blood count (increase in lymphocytes).

As regards mortality, recent figures taken from the Registrar-General's report for England and Wales (1923-1925) and dealing with the mortality for various occupations in the metallurgical industries, show the following returns:

Metal moulder, who, together with the unskilled foundry workers, form the large majority of wage earners in foundries (61,329 moulders out of 166,001 wage earners), show the mortality rate for all causes exceeding the comparative mortality figure (C.M.F.) by 13.7 per cent. for all ages, with the exception of the group between twenty and twenty-five years of age, the mortality rate for which only amounted to 95 per cent. of the general average, contributing to an excess which mounts gradually and reaches 34 per cent. for workers aged over seventy. The most frequent causes of death are influenza, cancer and respiratory troubles (bronchitis and pneumonia). These results thus cause moulders to rank amongst the most affected (135th, 162nd place) out of 178 groups, the latter figure designating the most seriously affected category.

Blacksmiths and mechanics, fitters, boilermakers and unskilled workers helping the latter show a mortality rate slightly under that of the general average, without however any exceptional rates for any special age group or any particular causes of death. Figures for plumbers and gasfitters are relatively high for chronic nephritis and cerebral haemorrhage. This high mortality is said to be due to lead poisoning, and the mortality due to lead amongst these workers is only exceeded by that for workers in the pottery industry.

Cutlery workers sometimes engaged in grinding and at others in polishing, are to a certain extent exposed to the inhalation of silica dusts. Their comparative mortality figure for all causes of death is 28 per cent. above the average, especially for the group aged thirty-five to fifty-five. The diseases which cause the greatest number of deaths are: syphilis, cardiac valvular troubles, accidents and pneumonia.

For file-cutters, see article "File-cutting".

Metal polishers show similar mortality rates, under which the outstanding causes are notably cancer of the stomach, influenza, pneumonia, etc. The phthisis rate is 2.12, and that for bronchitis 1.96 times the average figure (see also article "Metal Grinding and Polishing"). Riveters who work chiefly in the open air and are exposed to all weathers have a comparative mortality figure which exceeds the average by 6.2 per cent. It should be noted that amongst the causes of death the highest figure is that for syphilis, followed by bronchitis (excess of 60 per cent.), pneumonia (excess of 35 per cent.) and phthisis (excess of 15.7 per cent.).

Workers engaged in naval construction show a mortality rate which only amounts to 934. The unskilled workers in this occupation, however, show on the contrary a rate of 1,253, the most frequent causes of death being: influenza, phthisis, syphilis, cancer and especially cancer of the stomach, respiratory troubles and accidents.

Pathology

Amongst general troubles should be mentioned first of all those arising from fatigue, heart-stroke, exhaustion, cramp, anaemia, premature senility, etc., troubles due to cold (extremely
frequent: tonsillitis, acute or chronic rheumatism, respiratory affections, etc.; forms of poisoning due to products handled or to substances liberated during the various operations (lead, carbon monoxide, cyanide, nitrates, etc.).

Forms of illness similar to those caused by brassfounders' fever, and which are attributed to zinc fumes, affect very frequently workers engaged on cutting metal by means of a blowpipe. The incidence of lead poisoning among these workers attained very high figures after the war at the time when shipbreaking was frequently engaged in. Cutting painted metallic plates by blowpipe, where the ground coat consists of red lead, involves volatilisation of lead and causes inhalation of the fumes, giving rise to acute poisoning amongst the workers.

The use of red lead cement heated to 1,000°C for riveting in the construction of a metal bridge was the cause of poisoning amongst the workers who completed about 30 to 40 rivets per hour (Fraenkel, 1928). The use of a red lead cement heated to 1,000°C for riveting in the construction of a metal bridge was the cause of poisoning amongst the workers who completed about 30 to 40 rivets per hour (Fraenkel, 1928).

Reference should be made to the article "Nitrous Fumes" for information regarding the risk connected with red fumes liberated during scouring of metals with acid.

Forms of dermatitis occur on the uncovered parts of the skin and are manifested by pigmentation and erythema (in the case of exposure to the action of radiant heat and often in contrast with pallor of the mucous membranes) and are especially amongst blacksmiths (pigmentation of the mucous membranes and nodules) and amongst milling machine operators, due to small metal particles (Kober and Hayhurst). Blisters and carbuncles on the hands have a characteristic situating amongst certain occupational categories, for instance file-cutters. Horny callosities of this kind when neglected may develop into painful scars and even suppurate. Small traumatic lesions favour the formation of ulceration, and when they become infected may develop into subcutaneous cellulitis, whitlows, etc. Forms of dermatitis due to lubricating oils, and especially that known under the name of "oil acne", should also be mentioned (see article "Petroleum"), as well as "wearing" away of the nails encountered amongst workers removing sand from castings. The skin is often subject to ulceration which at times is extremely painful and is caused by certain products the action of which is accelerated by pre-existing skin lesions (broken skin, scratches, etc.).

The use of water and lubricating oils containing dichromate induces ulceration of the skin (see article "Chromium and Chromates").

In France in 1927 a case of papillomatosis of the forearm with cancerous degeneration was recorded as affecting a worker in a factory for making small metal balls. This lesion known as "turners' disease" led to amputation of the arm. The disease was attributed to the action of the tars (or mineral oils) used for lubricating.

Types of deformation of the bones have for long been known and described. Whilst in pre-war times knock-knees have been reported amongst file-cutters, turners and boring machine attendants who operate their machines with their feet, later deformations encountered are said to affect especially the thorax of workers engaged on turning machines. These deformations have been studied by several experts, amongst others by Sternberg. The right anterior and lateral part of the thorax reaching from the fifth rib downwards is pushed inwards, whilst the posterior part takes a convex form with the result that the right nipple is lower than the left. The muscles on the right side of the thorax, especially the large dorsal muscle, are more developed than those on the left side.

Metal workers also suffer from muscular curvature, especially in the lumbar region (blacksmiths), spasm, cramp and forms of paralysis of the muscles of the hand and forearm, amongst workers utilising compressed air tools: see article "Pneumatic Tools"). Certain workers engaged in making metallic lattice-work present, according to Dravet (1928), acute or chronic lesions of the tendons and synovial sheaths of the extensor muscles of the thumb and external radial muscles at the level of the anatomical snuffbox. This teno-synovitis is mostly bilateral. In cases where it is unilateral the left wrist is more often affected. Acute forms of this affection resemble in their clinical characteristics creeping teno-synovitis. Relapses are encountered especially as an effect of strain and exhaustion which is to blame for the first acute attack. The chronic form with chronic development from the outset causes partial permanent incapacity, and lesions of this kind develop very slowly without any acute symptoms which might serve as a warning.
A caustic or irritating local action has often been noted during several operations on metal work, and especially during welding. Lesions due to the fumes of the solution utilised (hydrochloric acid, zinc chloride, etc.) affect not only the mucous membrane of the eyes, but also of the mouth and upper respiratory passages (Koelsch) (see also article "Welding (Auto-genous)"). For injuries due to nitrous fumes, see article "Nitrous Fumes".

Whilst pathological manifestations affecting the digestive system are fairly frequent in foundries (gastralgia, gastritis, etc.), those of the respiratory system are more frequent. There has been noted irritation of the respiratory passages and bronchitis amongst metal grinders, obliterating bronchitis amongst workers handling metal hooks (Frederkel, 1908), pneumonia and forms of pneumono-coniosis (moulders, sand-spray workers, grinders, polishers), and sometimes even pulmonary haemorrhages due chiefly to metallic dusts (Kober and Hayhurst), tuberculosis amongst workers using the sandspray, yet isolated observations made lead to the conclusion that it is possible to find workers who have worked for fifteen, twenty years and over in occupations which include ocular fatigue, blepharitis, conjunctivitis.

No statistics are available relative to pathological conditions amongst workers using the sandspray, yet isolated observations made lead to the conclusion that it is possible to find workers who have worked for fifteen, twenty, twenty-five years and over in occupations which include ocular fatigue, blepharitis, conjunctivitis.

Valvular lesions and cardiac hypertrophy as well as derangement of the venous circulation due to prolonged standing or to strain have been described by several medical experts as occurring amongst founders, blacksmiths, brass-workers, mechanics, etc.

Ocular troubles encountered include ocular fatigue, blepharitis, conjunctivitis and in the case of certain occupations, cases of furunculosis due to obstruction of the sebaceous glands of the external auditory meatus have been noted, also deafness caused by noise and vibration. Ocular troubles encountered include ocular fatigue, blepharitis, conjunctivitis and in the case of certain
occupational categories, cataract and lesions of the retina (autogenous welding by the action of ultra-violet rays, etc.). Hirschberg has described under the designation "electrical ophthalmia" a syndrome characterised by lesions of the conjunctivae, the cornea and the retina. Crzellitzer quotes similar cases and Apfelbach in 1914 described about fifty cases of ocular lesions which he had met with in the metallurgical industries in Illinois and which were characterised by conjunctivitis, photophobia, abundant lachrymation, transitory blindness and, more rare, keratitis of the retina, forms of scotoma and alterations in the pigmentation of the retina, etc. In 1921 Roberts studied cases of cataract amongst English workers engaged in chain making. Cridland in 1923 made a study of similar cases amongst puddlers and Schnyder in 1928 amongst iron-workers.

Samoiloff (1926) has reported diminished sensibility of the cornea amongst metal-workers. The possibility of burns due to hot metal splashing has been already referred to.

Finally Lederer (1929), basing his observations on extensive statistical data, has arrived at the conclusion that workers employed in front of furnaces suffer from premature presbyopia more frequently than other categories of workers. As has been stated in regard to cataract, accommodation is more readily affected on the side most exposed to the action of the radiant heat.

Accidents amongst metal-workers are very varied in type: burns, crushing lesions, contusions, cuts, fractures, etc. Complications are also of frequent occurrence especially in the case of skin wounds, which are very liable to infection.

Though not quite recent, the data collected in 1909 by Peri comprising 4,014 metallurgical workers and mechanics who were the victims of industrial accidents, provides nevertheless some idea of the incidence of various medical and surgical forms of injury which occur in this occupational category. (See article "Iron, Pig-iron and Steel Industry.") More recent statistics prepared by G. L. Ron-lando (1923) deal with 27,426 accidents which occurred amongst the workers in the Spezia Arsenal during the period 1913-1922.

Certain authors refer to the high rate of alcoholic poisoning amongst these workers as said to be favoured by working conditions inherent to certain processes (radiant heat, etc.).

It seems of interest to refer to certain Russian studies on fatigue amongst metal-workers and in particular to those effected by Efimow and Zibakov (1925) in Moscow and Efimow and Itina (1925) which insist on the value of short rest periods throughout the working day as a means of prevention of fatigue amongst metallurgical workers; those of Feinberg (1925) who enquired into conditions amongst workers manufacturing rolling-stock and in particular amongst workers exposed to heat, his conclusions seeming to point to the fact that injuries encountered were largely due to variations in the surrounding temperature, to the action of radiant heat in the course of certain operations and to that of carbon monoxide (0.15 to 0.57 mg. per litre), sulphur-dioxide (0.10 to 0.14 mg. per litre) and to strain (muscular fatigue).

Hygiene.

Metal-working establishments are generally classified as dangerous trades on account of certain offensive features connected with them: smoke, steam, noise, vibration, etc. Certain legal requirements consequently demand that windows opening on to public highways or neighbouring properties should be kept closed, that machinery should not be installed alongside the common partition walls, in order to protect neighbours against noise and vibration, and that smoke, fumes and dust (sand-spray) should as far as possible be collected and removed.

Workrooms should be so constructed as to permit of satisfactory installation of the machine-tools, etc., of adequate ventilation and lighting of the workrooms, which should further be maintained in a satisfactory state of cleanliness. With this in view it is essential to have even uniform flooring and lime-washed walls.

Problems of ventilation and lighting receive in general adequate consideration from the technical managers of the factory, who are now increasingly aware also of the advantages which accrue from rendering factory conditions healthy as regards the problem of withdrawal of dust, smoke and fumes. The reader is referred to the various articles dealing with these problems. Brief reference may, however, be made to certain improvements which have been obtained in a number of factories as regards measures of general hygiene (dust exhaust, cooling of furnaces, lighting for hygiene) as applied to certain special operations (scouring of metals, etc.).
In work on ordinary metals it is essential to have arrangements for collection and evacuation of the abundant dust produced in the course of several operations (fig. 26).

As an instance may be quoted the operations of removing the moulds, fettling and rough-shaping the metallic articles in a dry state. For a suitable means of collecting the dust in accordance with the types of apparatus and the kind of process, technical experts have occasionally recourse to automatic precipitation of the dust, which is inadequate, and at times to ventilation by means of steam, compressed air, blowing or exhaust. See in this connection articles "Abrasives (Artificial)," "Metal Grinding and Polishing" and "Dusts, Fumes and Smokes".

Sandspray machines, the use of which has at present become increasingly extensive, require the adoption of minute precautions more especially by reason of the fact that the sand used is hard and siliceous. These measures vary slightly in accordance as to whether the article which is presented to the sandspray is fixed or whether the worker is obliged to direct the spray on to the articles. Respiratory masks of a good type give favourable results. It is, however, necessary to take into consideration the serious inconvenience of this protective appliance when the connection between the head-piece and the piping for provision of compressed air is badly made or becomes disconnected. In the event of this happening there is immediately a violent entry of a cloud of dust in suspension in the atmosphere and the worker is then perhaps obliged to breathe an atmosphere more injurious in its results than if he had been unprovided with a mask.

Fettling of small foundry pieces is generally done by hand with the aid of brushes. To overcome the inconvenience caused by inhalation of the dust liberated it would be advisable to effect this operation on benches provided with downward exhausts for withdrawal of the dust. Amongst the measures proposed by Middleton may be mentioned the installation of sandstone grinding by a wet process in a special chamber; abundant provision of water for the grindstones; wearing of respiratory apparatus; good general ventilation of the workshops together with adequate localised ventilation, where work is carried out in a dry state; and changing of shifts in order to ensure that the workers are not always exposed to the same dust. In the closed apparatus the heaviest grains of sand fall back into a sieve and from there into a reservoir. The lightest particles which have become extremely fine by a wearing down process fly about in the atmosphere and are usually withdrawn by localised ventilation and cast outside. It is, however, preferable to direct these dusts on to filters or on to a sheet of water or a layer of coke kept damp by a fine water spray (Frois). The best protection is obtained by the adoption of apparatus furnished with automatic devices (sandspraying machines in the bronze factories, closed apparatus preventing the worker from coming in contact with the dust), by utilising wet sand (mixture of water and sand in given proportions by means of compressed air at high pressure) and by the use of fine metallic shot (a costly system).

Scouring with acid should also be effected in such a manner as to prevent dispersion of acid fumes and the projection of droplets. The waste water should not be discharged until it has been neutralised, when it should be evacuated either by drainage or by discharge outside the factory and this only after every precaution has been taken to prevent stagnation and likewise every possibility of any inconvenience likely to be caused for those...
in the neighbourhood, and of any possible pollution of the water supply.

In workrooms adequate measures should be taken to prevent liberation of harmful steam, fumes, gas or dust. Acid fumes may be collected under excellent hygienic conditions even in closed workrooms by means of the device indicated in figs 27 and 28 (Association of Industrial Employers, Belgium).

On the upper surface of the three walls of the scouring vat there is arranged a wooden case closed on all sides except towards the interior of the vat. On its surface and as low as possible small exhaust apertures of a rectangular form are arranged. The long wooden cases are connected up by means of piping to an exhaust device which has the effect of withdrawing by exhaust as they form any fumes liberated at the surface of the bath and casting them outside through a chimney. A uniform rate of exhaust is obtained by giving the ventilation piping a cross section which increases from the furthest distant point up to the point at which it joins the exhaust piping. Another system of elimination of acid steam is composed of hoods placed above vats and connected up with evacuation piping. Ejectors fed by a steam pipe withdraw the gas towards the outside. Condensations produced in the evacuation piping are led back to the rinsing vats by means of purifying agents; vats and edges of hoods are installed in a box with glass windows balanced by means of counterweights; lattice work is furnished on the floor in front of this installation with a view to preventing the worker from treading on acid solutions.

Bachrach, of Rostov, who has made a study of conditions relative to metal scouring by acids in Russian factories, insists (1930) on the necessity for having rational ventilation of the workshops and on the advantage of adding to the solution in the vats certain special substances ("Sparbeize", "Adacid", "Antra", etc.), said to be of advantage from the hygienic and also from the technical point of view, and finally on the advisability of replacing chemical scouring by mechanical scouring (Tereschtschko), which would result in rendering the work in question perfectly healthy.

The best fire extinguisher for tempering baths is absolutely dry sand. The introduction of any water into nitrate baths should be avoided. Workers should be instructed as to the risk involved; no wooden articles should be allowed inside the workroom, which should be provided with safely doors opening outwards, and there should be ample provision of boxes containing very dry sand. It must be remembered that burns caused by molten nitrates are extremely painful and slow in healing, it being therefore necessary to adopt every possible precaution to prevent these (Grempe).

![Fig. 27.](image-url)
It is hardly necessary to insist here on the advisability of replacing wherever possible hand transport of articles of manufacture by lifting apparatus. Similarly, attention has on several occasions been called to the advantage of rest intervals, judiciously interspersed throughout the working shift with a view to preventing fatigue, and in this way to improving production both as regards quantity and quality.

The question of purification of waste waters in the metal industry is of capital importance and at the same time extremely complicated.

Amongst measures of personal hygiene should be included the provision of working clothes, aprons and leather leggings for workers (particularly those obliged to work under conditions of great heat), of gloves, glasses, head-gear and, where necessary, respiratory masks, etc. Washing accommodation, douches, baths, etc., as well as canteens, where these are required, should also be provided. An interesting account of social progress in the French metallurgical industry is that published by Pinot in 1924. See also the article "Social Welfare".

In all processes requiring scaffolding or in regard to all work effected in a dangerous position, adequate safety measures should be taken with a view to assuring on the one hand the solidity of the construction and on the other to preventing workers falling from heights.

Transport and first-aid for injured and sick workers should be assured by adequate means and entrusted to trained personnel.

The above measures should be completed by propaganda work amongst the workers in order to keep them informed of the dangers and risks to which they are exposed and of the requisite precautions to be adopted. Their attention should be drawn especially to measures of personal hygiene and graphic presentation of facts will be found to play an important part in this scheme of propaganda.

Legislation

Women are excluded in France from operations of scouring, pickling and galvanisation of iron in workrooms where acid fumes are liberated, or in which acids are handled and similarly from workrooms where grinding and polishing of metals are effected.
Young persons under fourteen years of age are excluded in Belgium from grinding operations, from polishing on mechanical grindstones articles intended for the manufacture of firearms, and, in Great Britain, from operations connected with dry grinding in the metallurgical industry. Young persons under sixteen years in Belgium are excluded from operations connected with coating iron and cast iron with zinc (in workrooms for scouring and coating with zinc); in South Africa from dry polishing; in several of the United States from work where abrasives are used in polishing articles made of non-precious metals on wheels or grindstones; young persons under eighteen years of age are excluded in France from work on sheet iron and painted metals when the use of toxic products is involved; and in certain of the United States as mentioned above.

Boys under fifteen years of age are in Italy excluded from operations on metal works or in Japan from any work in connection with metal where dust is liberated; boys under sixteen years of age are excluded in Canada (Quebec), from the cutlery trade (grinding) from dry polishing of metals and from vanishing of metals dried in a furnace and from the manufacture of nails, in Spain from polishing, grinding of metals and the preparation of painted metals wherever toxic substances are used.

Girls under seventeen years of age are excluded in Canada (Quebec), from similar operations to those given above in reference to boys; those under twenty-one years of age in Italy, Japan, Spain, under conditions similar to those already mentioned for boys.

Apart from general hygiene regulations which may be applicable to the metal industry certain legislatures contain special regulations relative to the industry in question. In Finland an Order of 1927 contains safety measures for metal shops; in France the Act of 19 December 1917 dealing with dangerous trades lays down conditions regarding the opening and running of workshops for metal scouring (with sand and acids), in regard to which provision is likewise made under Italian legislation.

In Germany instructions issued by the Ministry of Labour relative to the protection of the health of workers engaged in dismantling ships were issued on 26 April 1923. Orders of 2 February 1921 and 12 May 1927 deal with painting inside the holds of ships; they fix the length of the working shift for painters (shifts to last for half an hour separated by intervals of two hours on work in the open air); constant supervision of the workers; the number and size of the manholes in relation to the dimensions of the place in which the work is effected; adequate measures for the rapid and easy withdrawal of workers; prohibition of entering into freshly painted places prior to adequate ventilation; etc., are included.

Similar prescriptions have been issued for workers engaged in operations of welding and cutting by blowpipe.

General measures with a view to prevention of risk from lead colours (in course of painting operations) in shipyards are contained in the Order of 27 June 1905 which is from time to time extended and completed in the sense of more frequent examination of the workers.

In the case of repair of tank ships which have contained mineral oils, German legislation demands supervision by a responsible engineer or master of works, likewise preliminary emptying of the tanks by the introduction of air or steam to drive out any inflammable gases present therein; testing, prior to work, to ensure absence of toxic or inflammable gas, etc.; permission to descend into the tanks only to be granted in the presence of an engineer; constant ventilation of the tanks whilst workers are engaged therein; lighting of the tank by electric light and by a system excluding the possibility of risk from explosion, etc.

In Great Britain an Order of 5 October 1917 deals with the protection of workers engaged in making tin wares or ware with a tin coating. A further Order of 12 October 1917 deals with ambulance and first-aid work in metal factories, foundries and other metallurgical factories. An Order of 3 July 1918 lays down measures of protection for workers engaged in turning shells or shell cases, whilst a further Order of 31 December 1921 is devoted to the protection of workers engaged in the manufacture of tinware and galvanizing. A Regulation of 2 September 1925 deals with grinding and polishing of metals.

In Greece the prevention of accidents in the metal industries is dealt with under the Act of 23 December 1925.

In Norway a Royal Order dated 29 October 1920 contains hygiene regulations relative to polishing of metals, and a further Order dated 30 October 1919 deals with work in foundries.

In the U.S.S.R. several regulations are devoted to safety in workshops in the metal industry (forges, rolling-mills, etc., 1923), likewise.

Cases of dermatitis (eczema, etc.), pulmonary affections occurring amongst metal polishers, inflammation of the joints and of the subcutaneous cellular tissue and synovitis of the knee amongst workers in shipyards for maritime engineering as well as forms of teno-synovitis amongst blacksmiths, pulmonary affections and cataract affecting foundry workers and metallurgist's cramp are subject to compulsory notification in the Netherlands.

Compensation is granted for cases of poisoning (by lead, mercury, cyanides, asbestos, etc.), as well as for cases containing the list of diseases for compensation or covered by the definition of industrial accident or again by a list of
substances (Finland, Switzerland); likewise cases of silicosis or phthisis amongst metal sharpeners and polishers (Germany, Ontario, Alberta), where siderosis and lithusis are also compensated; cases of poriatis of the palm of the hand amongst the same workers (Japan); cases of deafness and hardiness of hearing (Germany); cases of cataract amongst metal founders (Germany); cases of cataract and retinitis amongst metallurgical workers (U.S.S.R.); cases of poisoning due to metals (Queensland, Western Australia); cases of neuralgia and neuritis of the extremities due to fatigue and pressure of tools, etc., amongst blacksmiths (U.S.S.R.). See also the article "Occupational Diseases: Definition and Compensation".

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MARSHAK, M., in Gigiena Truda, 1924, No. 9. Moscow.

See also the periodical publication of the International Labour Office, entitled: Bibliography of Industrial Hygiene.

The illustrations have been prepared from photographs kindly lent by the Belgian Medical Inspectorate (figs. 27 and 29).

Medical and Allied Professions
(Occupational Pathology of)


Doctors and Physicians

While more fortunate than men of letters in that they are not obliged to lead an entirely sedentary life, doctors are on the other hand forced to spend much of their time under conditions which are bound to exercise a pre-judicial influence on their health. In lecture halls or hospitals, in the midst of epidemics or with the army during campaigns — in fact everywhere where the doctor is exposed to infection and contagion. His whole life, divided between the claims of science and humanity, is sacrificed to duty; and in his concern for the health of others he has neither the time nor the inclination to look after his own (Layet).

At the present day, however, the doctor's sphere of activity is very much more extensive. He engages in general practice in the town or country or as specialist in chemical, serological, physical or pharmaceutical laboratories or works in röntgen-ray or radium centres (either for preparation or treatment), or in public service, in schools, factories, etc., and each and all of these activities may offer particular sources of injury to his health.

The traditional reluctance of the physician to heal himself is reflected in the fragmentary and inaccurate information to be had regarding the health conditions or even concerning the morbidity and mortality of the medical and allied professions.

RATES OF MORBIDITY FOR CERTAIN OCCUPATIONS
American Insurance Experience, 1921-1935

<table>
<thead>
<tr>
<th>Occupational group</th>
<th>Years of exposure</th>
<th>Average number of days' disability per year of exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>All occupations combined</td>
<td>461,716</td>
<td>4.46</td>
</tr>
<tr>
<td>All occupations excluding physicians</td>
<td>424,672</td>
<td>4.38</td>
</tr>
<tr>
<td>All occupations excluding dentists</td>
<td>404,474</td>
<td>4.43</td>
</tr>
<tr>
<td>Physicians</td>
<td>414,858</td>
<td>5.99</td>
</tr>
<tr>
<td>Dentists</td>
<td>29,199</td>
<td>6.88</td>
</tr>
<tr>
<td>Lawyers</td>
<td>10,705</td>
<td>5.53</td>
</tr>
<tr>
<td>Corporation officers (n.o.s.)</td>
<td>9,846</td>
<td>5.18</td>
</tr>
<tr>
<td></td>
<td>15,776</td>
<td>5.09</td>
</tr>
<tr>
<td></td>
<td>17,358</td>
<td>5.18</td>
</tr>
<tr>
<td></td>
<td>19,084</td>
<td>5.70</td>
</tr>
<tr>
<td></td>
<td>17,136</td>
<td>5.55</td>
</tr>
</tbody>
</table>

Omitting Policy Form " .05 " (see text)

| All occupations combined                               | 407,043           | 4.92                                                   |
| All occupations excluding physicians                   | 369,999           | 4.28                                                   |
| Physicians                                             | 388,630           | 4.18                                                   |
|                                                       | 393,438           | 4.26                                                   |
|                                                       | 18,423            | 4.98                                                   |
|                                                       | 16,501            | 4.60                                                   |

1 Figures in italics indicate years of exposure and rates for partial disability for policy holders eligible for partial disability benefits.
No extensive data are available regarding morbidity among physicians. It seems unlikely that they can have an abnormally high incidence of incapacitating illness. The principal causes of death, apart from a portion of the cardiac group, are not associated with long periods of disability.

The combined experience of a large number of American insurance companies writing personal health and accident insurance, published in 1926, shows, however, a relatively high financial loss ratio for physicians and surgeons. The following table presents data relating to the four most prevalent types of policies issued which, for all occupations combined, included over 97 per cent. of all years of exposure.

According to this experience, total incapacity among physicians and surgeons is 36 per cent. greater than for other occupations combined, 88 per cent. greater than among lawyers and 28 per cent. greater than among a general group of officers of corporations. Similarly, partial disability is 28 per cent. in excess of that of other occupations combined, 42 per cent. greater than among lawyers and 8 per cent. greater than among corporation officers. The greatest excess among physicians, however, is in connection with one type of policy providing for full disability irrespective of house confinement, and if this type be omitted from consideration, the total disability is but 19 per cent. in excess of that for other occupations combined, the partial disability 26 per cent. greater. This experience among physicians, apparently moderately unfavourable, must be in part explained by the fact that a liberal attitude is maintained by companies adjusting the claims of physicians. Age distribution figures little as policies are rarely in effect after the age of sixty.

An enquiry made by Kunzig deals with the hospital staff in the infectious diseases departments of the Düsseldorf hospitals for the period 1907-1927 and has provided the following data:

Amongst the doctors: 6 cases of diphtheria and 5 of scarlet fever, 2 of influenza accompanied by laryngitis, 12 of bad sore throat, 4 of typhus and typhoid jaundice, 1 of whooping cough, 1 of parotitis, and 1 of acute enteritis.

Amongst the nurses: 48 cases of diphtheria, 29 of scarlet fever, 13 of acute enteritis, 23 of bad sore throat, 184 of influenza, 3 of typhus (1920-1927), 1 of chicken pox, 3 of parotitis, 3 of whooping cough, 2 of influenza accompanied by laryngitis.

In 1928 Mignon published the results of research effected in studying the archives of a mutual aid society for French doctors for the period 1894-1924. The various groups of diseases with a duration exceeding four days are as follows:

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Number of patients</th>
<th>Number of cases</th>
<th>Number of days of incapacity</th>
<th>Number of deaths</th>
<th>Average duration of the cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grippe</td>
<td>585</td>
<td>887</td>
<td>21,081</td>
<td>6</td>
<td>94</td>
</tr>
<tr>
<td>Accidents</td>
<td>387</td>
<td>568</td>
<td>22,470</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>Cardiac affections and diseases of the blood vessels</td>
<td>90</td>
<td>105</td>
<td>51,446</td>
<td>38</td>
<td>412</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>48</td>
<td>62</td>
<td>50,380</td>
<td>22</td>
<td>812</td>
</tr>
<tr>
<td>Diseases of the nervous system</td>
<td>46</td>
<td>51</td>
<td>31,386</td>
<td>31</td>
<td>615</td>
</tr>
</tbody>
</table>

Diseases of the heart and blood vessels and then tuberculosis most frequently affect the medical profession. As regards age, the greatest number of cases of sickness fall within the period between the ages of forty and fifty and at fifty years of age there is recorded the greatest number of diseases. From twenty-five to forty-five the morbidity rate is stationary round about 2 per cent., it oscillates about 3-6 per cent. from forty-six to sixty years and above that age it mounts rapidly in a striking manner since the morbidity rate passes from 6 to 100 per cent. in twenty years (effect of old age).

Mortality statistics for physicians are subject to some degree of error because of the inclusion under the title of a great variety of occupations allied to that of the practice of medicine. The profession in all countries includes not only active practitioners, but also many who have retired or who are but casually engaged in practice, and those in laboratory research, in public health work and medical and institutional administration.

The deaths of physicians reported in the United States in 1923 amounted to 2,570, which, adding 2 per cent. for omissions and delayed reports, makes...
Mortality per 1,000 Male White Physicians in the United States, 1925, Compared with That for All Occupied Males, 1920 (U.S. Census Bureau), and for Physicians, 1910-1912 (Report of Registrar-General for England and Wales)

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Number of physicians, 1925</th>
<th>Deaths</th>
<th>Death-rate per 1,000</th>
<th>Death-rate all occupied males, 1920</th>
<th>Physicians, England and Wales, 1910-1912</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ages</td>
<td>134,361</td>
<td>2,544</td>
<td>18.9</td>
<td>18.9</td>
<td>16.91 (all ages)</td>
</tr>
<tr>
<td>20-34</td>
<td>99,289</td>
<td>54</td>
<td>2.7</td>
<td>4.9</td>
<td>6.71 (20-44)</td>
</tr>
<tr>
<td>35-44</td>
<td>31,575</td>
<td>928</td>
<td>6.4</td>
<td>11.9</td>
<td>16.48 (45-64)</td>
</tr>
<tr>
<td>45-54</td>
<td>41,518</td>
<td>464</td>
<td>11.9</td>
<td>16.5</td>
<td>16.84 (45-54)</td>
</tr>
<tr>
<td>55-64</td>
<td>24,793</td>
<td>590</td>
<td>24.2</td>
<td>26.8</td>
<td>16.67 (55-64)</td>
</tr>
<tr>
<td>65-74</td>
<td>15,058</td>
<td>681</td>
<td>56.3</td>
<td>73.4</td>
<td>16.8 (65-74)</td>
</tr>
<tr>
<td>75-up</td>
<td>4,165</td>
<td>153</td>
<td>313</td>
<td>153</td>
<td>146.28 (75-up)</td>
</tr>
</tbody>
</table>

The death-rates at the several age-periods for American physicians in 1925 given above are certainly conservatively low as the data upon which they are based were obtained from the files of the American Medical Association. In comparison with these, the rates for physicians and surgeons as reported by the registration states in 1920 perhaps err in being somewhat high.

DEATH RATES, REGISTRATION STATES, 1920

<table>
<thead>
<tr>
<th>10 to 13</th>
<th>14 to 19</th>
<th>20 to 24</th>
<th>25 to 44</th>
<th>45 to 64</th>
<th>65 and over</th>
<th>All ages from 65 onwards</th>
</tr>
</thead>
<tbody>
<tr>
<td>All occupations</td>
<td>1.42</td>
<td>4.24</td>
<td>5.97</td>
<td>7.06</td>
<td>16.48</td>
<td>84.89</td>
</tr>
<tr>
<td>Physicians and surgeons</td>
<td>—</td>
<td>—</td>
<td>5.97</td>
<td>5.68</td>
<td>19.60</td>
<td>100.53</td>
</tr>
<tr>
<td>Lawyers, Judges and justices</td>
<td>—</td>
<td>—</td>
<td>4.01</td>
<td>5.19</td>
<td>19.64</td>
<td>95.90</td>
</tr>
<tr>
<td>Clerks (except in stores)</td>
<td>—</td>
<td>—</td>
<td>5.48</td>
<td>8.01</td>
<td>20.82</td>
<td>79.33</td>
</tr>
</tbody>
</table>
The crude death-rate of 19.0 per 1,000 males, compared with a rate of 12.6 among all occupied males suggests a serious situation which does not, as a matter of fact, exist. A very much larger proportion of physicians than of professional groups or other occupied males lives beyond forty-five years of age. Physicians enter upon their work later in life than do most men and they do not figure in mortality tables at all until twenty years of age.

PERCENTAGE AGE DISTRIBUTION OF MALE WHITE PHYSICIANS, PROFESSIONAL MALE WHITES AND OCCUPIED MALE WHITES

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Physicians (all groups excluding physicians)</th>
<th>Occupied males (excluding physicians and professional groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 44</td>
<td>Per cent 50.9</td>
<td>Per cent 68.3</td>
</tr>
<tr>
<td>45-64</td>
<td>Per cent 41.7</td>
<td>Per cent 27.0</td>
</tr>
<tr>
<td>65 and over</td>
<td>Per cent 8.1</td>
<td>Per cent 4.8</td>
</tr>
</tbody>
</table>

² From U.S. Census, 1930, Vol. IV, Ch. 4.

It is the very longevity of the profession which is responsible for the high crude death-rate. Casper, writing in 1884 upon the expectancy of life for physicians, was extraordinarily pessimistic regarding their longevity and his views have long influenced those who have written upon the subject. Layet in 1875 reported the average age of physicians in England to be 45 years. Ogle in 1886 found the average duration of life of English physicians to be 59.3 years. De Wilde in 1925, reporting upon a group of Dutch physicians who have died since 1861, found the average age at death to be 50.6 years as contrasted with 64.8 for the average of the whole male population for the same period. The average age at death is not however in itself a valuable criterion of longevity. Unfortunately, life tables for any occupational group are very few.

Hill has computed the expectation of life for English physicians, comparing it with that for all males (see table).

The report of the Registrar-General for England and Wales (1910-1912) shows for physicians 693 deaths in the "standard population" against 790 for all occupied and retired males aged twenty-five to sixty-five, and 695 for the upper and middle social classes. Favourable as this rate seems, it is higher than that for the legal profession (627) or for clergymen (443). These figures are corrected for age distribution, and are, consequently, significant. It should be noted that no deaths beyond the age of sixty-five are included. The death-rates per thousand living are slightly higher for the several age-groups than those found for American physicians in 1925.

Bertillon, summarising extensive mortality statistics for England, Scotland, Paris, France and Switzerland, found the death-rates for physicians, in relation to the general average, to be slightly higher in the earlier English, Scotch, French and Swiss figures and lower in the Parisian and later English tables.

According to Koelsch, the mortality rate for German doctors and veterinary surgeons exceeds that for other professional classes, but does not exceed the general average. The excess mortality is manifested especially in cases of circulatory disease, infectious diseases, and diseases of the nervous system.

With good reason, diseases of the heart and arteries have long been considered the great cause of death among physicians. Harvey, Hunter, Jenner, Bright, and Ramazzini are but a few of those whose deaths were due to cardiovascular disease, such as angina pectoris or apoplexy. Statistical data from many sources indicate that cardiovascular disease is the outstanding cause of death of medical men.

An analysis of 2,534 causes of deaths (United States, 1923) gives the following results:

**EXPECTATION OF LIFE OF ALL ENGLISH MALES BASED UPON MORTALITY: (1) 1838-1854 AND (2) 1910-1912, AND (3) EXPECTATION OF LIFE OF PHYSICIANS, SURGEONS, AND REGISTERED PRACTITIONERS BASED UPON THE MORTALITY OF 1910-1912**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>29.4</td>
<td>31.7</td>
<td>32.7</td>
</tr>
<tr>
<td>40</td>
<td>29.1</td>
<td>31.7</td>
<td>29.7</td>
</tr>
<tr>
<td>45</td>
<td>29.8</td>
<td>33.9</td>
<td>34.7</td>
</tr>
<tr>
<td>50</td>
<td>30.5</td>
<td>36.2</td>
<td>31.7</td>
</tr>
<tr>
<td>55</td>
<td>33.5</td>
<td>37.6</td>
<td>31.1</td>
</tr>
<tr>
<td>60</td>
<td>34.8</td>
<td>38.1</td>
<td>31.4</td>
</tr>
<tr>
<td>65</td>
<td>36.8</td>
<td>39.0</td>
<td>31.4</td>
</tr>
<tr>
<td>70</td>
<td>39.5</td>
<td>40.0</td>
<td>31.5</td>
</tr>
<tr>
<td>75</td>
<td>41.5</td>
<td>40.5</td>
<td>31.5</td>
</tr>
<tr>
<td>80</td>
<td>43.2</td>
<td>41.0</td>
<td>31.5</td>
</tr>
<tr>
<td>85</td>
<td>44.7</td>
<td>41.5</td>
<td>31.5</td>
</tr>
</tbody>
</table>
Diseases of the heart and circulatory system 309
Carcinoma and sarcoma 160
Tuberculosis 72
Diabetes mellitus 38
Septicaemia 37
Acute anemia 22
Typhoid 5
Beri-beri 1

Cerebral haemorrhage caused 260 deaths, general paralysis 11, meningitis 10, neuritis 7, epidemic (lethargic) encephalitis 10, brain tumours and other diseases, nervous system 26. Pneumonia claimed 161 victims, bronchitis 71, influenza 53 and other respiratory diseases 20, appendicitis 30, gallstones 18, cirrhosis of liver 15, strangled hernia 12, acute indigestion 14, biliary calculi 6, other digestive diseases 52, chronic nephritis 100, uremia 30, diseases of the genito-urinary system 21, bone diseases 6, senility 422, sequels to diseases of the nervous system 21, bone diseases 6, senility 422, sequels to operations 119.

Data assembled by the American Medical Association and studied by Emerson and Hughes show the following death-rates among American physicians in 1925 for the ten most important causes.

<table>
<thead>
<tr>
<th>Causes of death</th>
<th>Rate per 100,000 (all ages)</th>
<th>25-44 years</th>
<th>45-64 years</th>
<th>65 years and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease</td>
<td>363.9</td>
<td>79.1</td>
<td>383.4</td>
<td>1,187.2</td>
</tr>
<tr>
<td>Lobar pneumonia</td>
<td>145.1</td>
<td>61.7</td>
<td>141.0</td>
<td>494.4</td>
</tr>
<tr>
<td>Apoplexy</td>
<td>139.1</td>
<td>13.5</td>
<td>133.9</td>
<td>467.4</td>
</tr>
<tr>
<td>Cancer</td>
<td>87.0</td>
<td>38.9</td>
<td>80.7</td>
<td>172.2</td>
</tr>
<tr>
<td>Nephritis</td>
<td>85.5</td>
<td>38.9</td>
<td>80.7</td>
<td>172.2</td>
</tr>
<tr>
<td>Anginapectoris</td>
<td>74.4</td>
<td>9.6</td>
<td>86.0</td>
<td>233.7</td>
</tr>
<tr>
<td>Senility</td>
<td>65.5</td>
<td>—</td>
<td>54.3</td>
<td>—</td>
</tr>
<tr>
<td>Accidents</td>
<td>64.0</td>
<td>46.3</td>
<td>55.8</td>
<td>158.8</td>
</tr>
<tr>
<td>Suicide</td>
<td>45.4</td>
<td>35.1</td>
<td>57.4</td>
<td>61.5</td>
</tr>
<tr>
<td>Tuberculosis, respiratory</td>
<td>35.0</td>
<td>32.8</td>
<td>39.9</td>
<td>24.6</td>
</tr>
</tbody>
</table>

If the several forms of cardiovascular disease, excluding nephritis, be considered as a group, they account for 609.4 deaths per 100,000, 32.1 per cent. of all deaths. A similar proportion was evidenced by the mortality tables of the U.S. Census for 1909 — 31.3 per cent.

Comparing the mortality of physicians for important causes at the several age-periods with that of all occupied males, and particularly with that of males over twenty-five years of age, a number of striking facts are disclosed.

The excessive mortality of the medical profession from heart disease and the pneumonias is evident. Relatively very low rates may be noted, however, for cancer, nephritis and pulmonary tuberculosis. In the U.S. Census figures for 1900 cardio-vascular disease was dominant, but the pneumonias did not occupy so prominent a place, relatively.

English mortality statistics, quoted by Lowy, give the following rates: 10.5 pulmonary tuberculosis, 12.5 respiratory diseases; 13 circulatory diseases; 10.9 digestive diseases; 7.9 uroepithelial affections; 4.3 tumours; 12.3 diseases of the nervous system; 1.4 alcoholism; 4.4 suicide; 3.7 accidents and 16.1 other causes. Statistics for 1910-1912 present for doctors a tuberculosis mortality rate per thousand persons from fifteen to sixty-five years of age of 1.21 and a total mortality rate of 8.03. The percentage of the tuberculosis rate as...
compared to the general mortality rate is 15.07.

Out of 4,354 persons belonging to the medical and dental professions who were members of an insurance society there were during the year 59 cases (1.3 per cent.) of rheumatism distributed as follows: arthritis 12 cases, sciatica 13 cases, lumbago 15 cases, muscular rheumatism 13 cases and acute and sub-acute rheumatism 6 cases (Willcox).

In Italy the mortality rate for men of fifteen years and upwards from the most common diseases was for the years 1915-1917 as follows (figures relative to 100 deaths from all diseases for the same professional class):

<table>
<thead>
<tr>
<th>Disease</th>
<th>1915</th>
<th>1916</th>
<th>1917</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nephritis</td>
<td>9.8</td>
<td>9.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Doctors and veterinary surgeons</td>
<td>6.2</td>
<td>8.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Diseases of the liver</td>
<td>1.7</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>All professions</td>
<td>3.9</td>
<td>1.7</td>
<td>2.8</td>
</tr>
</tbody>
</table>

The low mortality from pulmonary tuberculosis among physicians has long been noted by Ogle and others. Recently Löwy expressed the belief that among younger physicians (from twenty-five to thirty-four years of age) there is the same incidence of tuberculosis as in the general population, and he stated that Teleky concluded from statistical evidence that in this age-group the mortality from tuberculosis was approximately that of the general population.

Hamel found that among the physicians and nurses employed in hospitals, university clinics and tuberculosis sanatoria the rates of infection were relatively low.

### Tuberculosis Infections among Physicians and Nurses Per Year, Per 100 Exposed

<table>
<thead>
<tr>
<th></th>
<th>Tuberculosis Infections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Physicians</td>
</tr>
<tr>
<td>General hospitals</td>
<td>0.99</td>
</tr>
<tr>
<td>University clinics</td>
<td>1.33</td>
</tr>
<tr>
<td>Tuberculosis sanatoria</td>
<td>0.08</td>
</tr>
</tbody>
</table>

A relatively large number of doctors have sacrificed their lives to scientific research or in the humanitarian task of prophylaxis. Martyrs in this cause include, amongst others, the following names: Daniel A. Carrion (verruga Peruana); Jesse W. Lazear, Hideyo Noguchi, Adrian Stokes, Col. Guilliet, William A. Young (yellow fever); Alexander Yersin, Herman Franz Muller (plague); Tito Carbone (undulant fever); Allen MacFayden (undulant fever and typhoid fever); Thomas B. McClintic (Rocky Mountain fever); B. Siccardi (haemorrhagic spirochosis); Ahmed Bey and Rudal Bey (glanders); Ottokaro Horak (tuberculosis of the skin); Pirrie (kala-azar); Howard Taylor Ricketts, Bacot (typhus); Moreschi (smallpox); Snyder (rattlesnake poison), etc., without taking into account the still greater number of doctors who have sacrificed their lives in research on X-ray work and radio-active substances.

### Pathology

Doctors are liable to all skin affections, and in particular to the anatomical tubercle and dermatoses due to iodoform, disinfectants used in preparation for surgical operations and to handling plaster of paris, and which are of frequent occurrence. In earlier times, before the wearing of rubber gloves to protect the skin, eczemas due to carbolic acid, sublimate and iodure solutions often even prevented surgeons from pursuing their careers. Erysipelas or some form of mycotic disease is secondary infections.

Schosserer reports from a surgical clinic, 1914-1921, 618 cases of skin infection contracted by members of the medical staff while treating approximately 144,000 patients, giving a ratio of 4.3 per thousand, which ratio diminished during the war years only to increase to 5 per thousand in 1919-1924. Medical students, some of whom contracted wounds during dissection, were however included, while about one-third of the cases affected nurses; 155 cases were by direct contact (hands, clothing, etc.) and the rest were secondary infections.

A very serious occupational malady developed by certain members of the profession has resulted from excessive exposure to röntgen rays and radio-active substances (see articles “Röntgen Ray Operators” and “Radium and Radioactive Substances”). Treatment with an arc lamp is said to expose the doctors handling it to poisoning by nitrous fumes (Dallex, 1927). The manipulation of radium and radio-active products is said to have caused cataract affecting a doctor (Elschnig,
1929. Naujokas in 1929 studied the action of X-rays on the reproductive function amongst assistants in radiological laboratories (for details see article "Röntgen Ray Operators").

Infection is certainly the gravest occupational risk for hospital staffs. Hamel found that the probable infection rate per annum and per hundred exposed was 0.14 for doctors of general hospitals, 0.35 for those in university clinics, and 0.08 for those engaged in tuberculosis sanatoria.

At the St. Ladislaus Hospital for Infectious Diseases, Budapest, from 1918 to 1924 there occurred 12 cases of infection (4 fatal) amongst clerks, and from 1910 to 1925 630 cases of infection (30 fatal) amongst nurses and 78 (9 fatal) amongst servants, laundry-women, cooks, etc.

During thirteen years up till 1929 the incidence of infections amongst persons occupied in scientific laboratories was, according to Kisskalt, as follows: 19 cases due to pure typhus cultures (confirmed cases); 13 cases of infection (probable cases); 22 cases of probable infection by cultures, contact with faecal matter or urine; 3 cases of infection (confirmed); 5 cases (probably by contact with faecal matter or blood); 8 cases of infection into the system by bacteria but without resulting disease. Amongst the cause or causes of infection there are found to be noted para- typhus A, cholera, diphtheria, anthrax, strepto-cocci, etc.

Infections amongst doctors are generally caused by wounds inflicted in course of handling hypodermic needles, medical and dental instruments, etc. Numerous other cases of infection occur however by direct contact with communicable diseases. It is a tribute to the care taken by most physicians that of the infectious diseases pneumonia alone now plays a prominent role as a cause of death. There are, however, unfortunate exceptions to this rule.

Surgeons, gynaecologists and staffs of bacteriological laboratories, of dissecting rooms, etc., are most exposed to infection. Though Ramazzini believed in the relative immunity of doctors as regards infection, and though it may be considered that doctors, by reason of their medical knowledge possess a strong protection against infection, yet the history of medicine reveals instances which prove the contrary, as in the case of Müller, of Vienna, who in 1898 died a victim to the plague which he had been studying in detail; or again in the case of four doctors and ten veterinary surgeons who were victims of glanders in a total of 106 cases, while a number of doctors have suffered from infections of the following order: tularemia, melitensis, spirochetosis, ictero-haemorrhagia, sittacosis (1930), etc. Doctors have also suffered from such infectious diseases as measles, scarlet fever, diphtheria, typhus, typhoid fever, malaria, and, amongst diseases transmitted by animals, anthrax, foot and mouth disease, etc. Cases of septicaemia, often fatal, are also frequent resulting from infection in dissecting rooms (Bichat, Legros, Papillon, etc.). These were formerly known under the name of "anatomical mephitism".

Throat specialists are specially exposed to infections, for example conjunctivitis; pathologists to the anatomic tubercle, typhus, typhoid fever and relapsing fever, etc.; bacteriologists to typhoid fever (Widal's reaction), typhus (case of E. Weil), spirochetosis, ictero-haemorrhagia (Siccardi), etc.; oculists to trachoma, ictero-haemorrhagia, etc. There should also be mentioned cases affecting medical scientists who have had themselves inoculated with pathogenic germs or have swallowed substances in order to study their properties.

As regards tuberculosis the highest rate reported by Hamel for university clinics (1.23 per cent.) was about the same as that for the general population. In Bavaria, Koelsch only found 1.92 per cent. as compared with 3.07 per cent. for the whole population. Those cases in which occupational origin could with certainty be affirmed were few in number in the statistics assembled by Hamel. Under present conditions in sanatoria there is practically no danger of infection for doctors (see later for nurses). A case of percussion, periostitis of the phalanges, has been met with in a doctor.

An abundant literature testifies to the frequency of extra-genital syphilitic infections amongst members of the medical profession. Trüb in a detailed monograph upon the subject, in which he analyses 669 cases due to exercise of the medical profession, distributes them in their order of frequency as follows: infection of extremities: finger, hand, arm, 388 times; eyes, 32 times; lips, 12 times; nose, 10 times; cheeks, 10; chin, 6; forehead, 2. (Some of the cases enumerated relate to midwives and 17 to dentists.) The cases of extra-genital syphilis affected in 19.5 per cent. of the instances midwives, in 13.0 doctors, and 11.7 dentists. Gynaecologists and surgeons are particularly exposed to this infection. Doctors are liable to infection
in treating patients (cases of Desmarres, Leloir, Boucheron, Buret, Hutchinson) and also from corpses during dissection (cases of Julien, Lagneau, Rumpf, Taylor). Thirty cases are on record, contracted by doctors and attendants during dissection, but only 5 of these stand the test of analysis and proof (Ullmann). It must also be remembered that doctors infected by syphilis may contract parasyphilitic diseases such as tubes, creeping paralysis, etc. (see article "Syphilis").

Venereal diseases of the eye have been contracted by doctors by rubbing the eye with an infected finger. Statistics of Bulkeley, Fournier, Scheuer, and Münchheimer show that in 1,000 cases of extragenital syphilis — chiefly infection of hands and fingers — 33, or 3.3 per cent., affected doctors. In the assembled statistics of the above, there were 952 cases of arm, hand and finger ulcers, of which 284 affected doctors. Of eye ulcers 40 per thousand, or 4 per cent., of the affected doctors — got by rubbing or by sputum of patients who had coughed in the doctor's face. Infections of lips, buccal cavity and tonsils are much rarer (Trüb). Trüb notes a marked recent decline in the frequency with which such cases are reported, reflecting improved measures of control of the disease and better technique; yet it must be remembered also that medical men frequently neglect to report such infection for fear of injuring their practice.

As an example of cancer infection transmitted from patient to physician, mention must be made of the case of a medical student, reported by Locène and Lacassagne (1926), who in extracting by puncturing a collection of pus which may have existed for months, introduced infected matter when treating patients, and also from corpses during dissection, but only 5 of these stand the test of analysis and proof (Ullmann). It must also be remembered that doctors infected by syphilis may contract parasyphilitic diseases such as tubes, creeping paralysis, etc. (see article "Syphilis").

Irritation of the mucous may lead to bronchitis, etc. Surgeons also suffer from flatfoot and varicose veins. Carbolic poisoning, sometimes fatal, was formerly fairly frequent when, in accordance with Lister's methods, doctors operated in an atmosphere rich in phenic acid fumes.

Pulmonary emphysema is said to be fairly frequent amongst doctors practising in mountainous countries; sclerosis of the coronary arteries with the well-known symptomatology is also said to be fairly frequent amongst doctors (Selig, quoted by Löwy), extra systolic neuritis (Galili).

Neurasthenia, another disease said to be of frequent occurrence amongst medical men, is due to hard and exhausting work and to grave responsibility, added at times by the influence of unduly heavy drinking and smoking, etc.

Doctors sometimes become addicted to drugs (morphia, cocaine) as a result of handling these therapeutically. Lambert has stated that of 1,700 cases of drug addiction in private practice, known to him, 405 were physicians. In 183 of these cases overwork and worry were apparently the causative factors and most of the cases developed in the late twenties or early thirties.

Out of 64 cases studied by E. Meyer, 21 affected doctors, 7 pharmaceutical chemists and druggists, and 2 male nurses; of 18 cases amongst women, 9 affected nurses and 3 doctors' wives. All the victims of cocaine who came under Löwy's observation were doctors or dentists. Usually this habit is met with in large towns rather than in country practices. Bertillon has commented upon the sobriety of the Parisian physician and the relative inebriety of his English counterpart. Whatever the record may once have been, alcoholism is not now notable as a cause of death of physicians in England. It does not figure as a cause of death in current American statistics.

The danger is naturally greater for doctors working in hospitals or laboratories. Hospital doctors are exposed to infectious diseases (tuberculosis, diphtheria, typhus, pneumonias, etc., contagious skin diseases, itch, furunculosis, etc., and venereal diseases). Infection may occur by pollution of water or food, by inhalation of dust, by bites (insects or parasites) or by spraying with infected matter when treating patients, or through open wounds or scratches.

Rist, who examined 349 members of a hospital staff for an insurance com-
pany in Paris, draws attention to current errors in the diagnosis of tuberculosis. He engaged in 1,032 consultations and personally supervised thorough and repeated chemical, radiological and bacteriological examinations with the result that he found amongst those previously suspected as tuberculous 9.3 per cent. really suffering from tuberculosis, amongst those stated to be tuberculous 33.3 per cent., and amongst those said to be suffering from open tuberculosis 86.6 per cent. — in all, 123 cases of tuberculosis, while 20 cases remained for further observation. The affections wrongly diagnosed were for the most part non-tuberculous pulmonary affections (24 cases) and affections of the upper respiratory passages (87 cases).

Special difficulty is encountered by medical staff in combating epidemics in mental asylums and hospitals where patients cannot be relied on to take precautions against infection; it is therefore found that a relatively high percentage of doctors, nurses and attendants contract infection during such epidemics, exanthematic typhus, etc. It has moreover been stated that as a result of the bad influence of mental patients on their attendants, amounting almost to a sort of infection, the working capacity of such attendants is reduced to nothing at the end of six to nine years, but owing to the large turnover in such institutions it is difficult to find absolute proof of this.

Staffs of laboratories, dispensaries, anatomy and dissecting rooms, disinfecting stations and baths, etc., also present special pathological features. Cuts and wounds received in dissecting rooms where infected substances are handled, as well as during post-mortem examinations, pave the way for infection from open corpses. The use of fixing solutions with a basis of formaldehyde, mercury, chromates or other substances may set up irritation — even chronic irritation of the mucous membrane involving risk of throat, nose and lung diseases and conjunctivitis.

The attendants in baths where the water and mud are rich in salts often suffer from irritation of the skin. Thus, for example, at Moinaki (Russia) peat-bath attendants were noticed to be suffering from skin irritation and other troubles ascribed to handling of lye and peat salts, sweat and dirt, and bent attitude sending blood to the head while transporting peat and attending to baths. Hydrogen sulphide fumes were inhaled by these workers, who suffered from trauma, nervous and muscular troubles, headaches and faintness, irritation of mucous — conjunctivitis, blepharitis and bronchitis. Skin troubles on hands and feet suggested an occupational disease, and 55 per cent. of illness was found to be confined to skin affections. It was noted that the workers suffered from loss of weight and reduced disease resistance at the end of the season.

Data regarding mortality and morbidity rates for the dental profession are even more fragmentary than those for physicians. No trustworthy mortality rates for this profession have been found except unpublished figures for American dentists indicating a mortality rate but little more than half that for physicians.

Both dentists and dental hygienists are exposed to the risk of contracting infections of the upper respiratory passages as a result of their professional work. There is also risk from infection (measles, diphtheria, tuberculosis of the skin, lupus, tuberculosis verrucosis cutis, etc.). There is, of course, some opportunity for contracting syphilis (finger infection) from the buccal lesions of patients. Usually it is the first finger, middle finger or thumb of the right hand which is affected. Because of the peculiarly faulty posture long maintained while operating, these groups have a tendency to develop deformities of the spine and shoulders with consequent cardiac troubles. Flatfoot in said to be common, associated with long continued standing, much of the time with practically all weight borne on one foot.

An interesting condition associated with the practice of dentistry is the dermatitis produced upon the hands by novocain or procain widely used by dentists. The condition is characterised by erythema, pruritus, exfoliation and fissuring, occasionally papules or vesicles, either on the dorsal or palmar surface of the hand.
More often formerly than of late dentists developed mild mercurial poisoning from the practice of rubbing up material for amalgam fillings in the palm of the hands. Hippe is said to have found mercury, not only in the atmosphere of a dentist's room, but also in the dentist's urine.

The use of X-rays exposes dentists to the risk of radio dermatitis with all its grave consequences. According to Klein, 17 per cent. only of a group of dentists examined were free of occupational disease; 72 out of 140 suffered from nervous troubles, deformities of the thorax, etc.

Risks of poisoning and asphyxiation from gas is present in operating theatres, dispensaries, disinfected and chemical laboratories and hygienic, pathological and anatomical institutes. The staff in these places are also exposed to danger from fire and explosion. Bursting of glass vessels and apparatus has also been the cause of accidents (eye injuries, etc.) in laboratories, dispensaries, etc.; where electricity is used, earthing and short circuits constitute a further danger.

Medical and Hospital Staff (Nurses, etc.)

In considering the morbidity and mortality rates of these workers, the part played by certain very unfavourable general factors must be taken into account; these, in a lesser degree, apply also to doctors. These comprise unduly long spells of duty, night duty, lack of sufficient exercise and fresh air, anxious and harassing responsibility, danger of infection added, in the case of religious orders, to fasting and strict exercise of religious duties, irregular meals, poor food, poor housing and unsuitable clothing. Amongst the latter anaemic and weak-chested subjects are often found, and not infrequently young nurses are obliged to do heavy physical work such as housework as well as sick nursing. An enquiry in regard to hours of work conducted in Germany showed that among 100 nurses 40.2 worked thirteen to fourteen hours per day, 41.2 worked fourteen to seventeen hours, and only 18.6 less that thirteen hours. Sometimes night duty or part-time night duty is demanded in addition to day duty. In private nursing (serious cases) the nurse is sometimes obliged to work twenty-four hours a day. For the great majority of nurses there is no legal limitation of the working day. All religious orders are exempt from regulations limiting the working week to sixty hours, or ten hours a day (Germany), and it is stated that this regulation where it applies is frequently not observed. The long hours and arduous routine life of the pupil nurses in many hospitals are a disgrace to the medical profession.

STATISTICS

No comprehensive mortality statistics for nurses are to be had. In the United States Census Bureau reports for 1909 the percentage distribution of deaths by causes was much the same as for all occupied females and for those engaged in domestic service. Typhoid fever was slightly higher.
and pulmonary tuberculosis notably lower. Typhoid fever is now, of course, largely eliminated through the use of vaccines. A report of medico-actuarial investigation of the experience of American insurance companies published in 1913 showed the actual mortality of trained female nurses to be 81 per cent. of the "expected", the same as that among unmarried women as a class.

There is no important evidence that nurses in general suffer a notably high death or illness rate as a result of contact with communicable diseases. In many American and European hospitals, however, acute illness among nurses, particularly young pupil nurses, is astoundingly prevalent. It is for the most part of types associated with debility resulting from long continued fatigue.

Despite the arduous life of nurses, most of the American reports relative to morbidity rates amongst them indicate these to be slightly lower than that for the general population, a proportion which might indeed be expected if the high physical standard demanded for this occupation be taken into consideration.

Robert Koch in 1910 carried out the first enquiry into the incidence of tuberculosis amongst German hospital staffs. For the period 1906-1910 the staff of 549 hospitals having a minimum of 100 beds showed a morbidity rate for tuberculosis of the lungs and of the larynx which did not exceed the average for the general population. Not one single group presented a value exceeding 1 per cent. Amongst the nurses in religious orders the morbidity figure seemed to be even more favourable than that for lay organisations of nurses not belonging to organised bodies.

Bräuning in 1910 arrived at similar conclusions; nurses from evangelical sisterhoods were not more frequently attacked by pulmonary tuberculosis than were women in the average amongst the active population. Nevertheless, 15-30 per cent. of the cases of tuberculosis were probably of occupational origin.

The German Council of Public Health decided in December 1922 to repeat the enquiry made in 1910 into the incidence of tuberculosis amongst the hospital staff. The enquiry will cover the period 1928-1931. In 1929 Harmsen studied the morbidity and mortality rates of nurses in evangelical sisterhoods. His enquiry covers a ten-year period.

In Italy, very interesting sickness and mortality statistics for nursing staffs have been furnished by G. d'Este and Chincarini. The former studied pathological conditions amongst nurses in Florence, and the latter those of the nursing staff in the "Maggiore" Hospital in Milan. The data assembled by D'Este cover a period of eighteen years (1904-1921), comprising eleven pre-war years (1904-1914) and three post-war years 1919-1921.

The days of absence for each individual nurse and for each case of sickness are summarised in the following table:

<table>
<thead>
<tr>
<th>Period</th>
<th>Per Nurse</th>
<th>Per Case of Illness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st period: 1904-1909</td>
<td>32.8</td>
<td>24.1</td>
</tr>
<tr>
<td>2nd period: 1910-1914</td>
<td>22.9</td>
<td>15.9</td>
</tr>
<tr>
<td>3rd period: 1915-1918</td>
<td>21.4</td>
<td>14.9</td>
</tr>
<tr>
<td>4th period: 1919-1921</td>
<td>18.6</td>
<td>16.2</td>
</tr>
</tbody>
</table>

After analysis of the cases of sickness as regards their duration, etc., D'Este is led to the same conclusions as Dr. Maffei (1914), who after studying absence due to illness amongst nurses in Florence concluded that the permanent staff of the hospitals remained absent from work on account of sickness for a number of days exceeding considerably that actually necessitated by their illness.

In analysing the incidence of diseases in relation to special categories, he found that the staff in the different departments were not presented an actual rate of absence per case of illness highly exceeding that for nurses in the tubercular wards (28.5; 18.3; 14.6; 13.7 as compared with 9.6). The explanation is to be sought in the working conditions for the latter category, which comprised a working day of eight hours in the twenty-four instead of eleven for the other services, and also in the fact that the nurses in the tubercular wards received an attendance bonus which was not paid during absence on account of sickness.

There were 19 cases of death: 11 due to respiratory diseases (6 to tuberculosis and 5 to broncho-pneumonia); 3 due to circulatory diseases; 2 due to digestive diseases and 2 to diseases of the liver, etc.

The mortality percentage was 1.91 per annum.

The morbidity rate per hundred male nurses was 71.1 for the period 1904-1909, 72.7 for 1910-1914; 76.5 for 1915-1918 and 62.8 for 1919-1921. The morbidity rate per hundred male nurses absent on account of sickness was per annum for the same periods 155.8; 151.2; 143.2; 114.9 respectively; each sick nurse having had during these four periods 1.08-1.09 attacks of sickness per annum. The general average sickness rate for Florence was 135 per cent.

The average number of days of absence for each case of sickness during the eighteen years under review was 17.77. As regards female nurses, the author was able to obtain data covering a period of twelve years: 1910-1921. The average number of women nurses employed being about 170 per annum, the number of patients amongst them amounted to 1,08 with 104 cases of illness and 2,744 days of absence, and an individual average of 16.1 days of absence and an annual mortality of 0.68 per cent. These data confirmed those already assembled in 1907-1909 by Guerra-Coppioli and those of Maffei in 1914.

The data collected by Chincarini for the period 1904-1914 and that for 1914-1921 throw very interesting light on the pathology and mortality of hospital workers.
In fact, for the second period the statistics relate to an annual average of 752 nurses (601 women and 151 men). The data may be grouped as follows:

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of nurses</td>
<td>1,909</td>
<td>4,809</td>
</tr>
<tr>
<td>Number of diseases</td>
<td>895</td>
<td>3,883</td>
</tr>
<tr>
<td>Number of deaths</td>
<td>16</td>
<td>50</td>
</tr>
<tr>
<td>Days of absence</td>
<td>16,502</td>
<td>60,558</td>
</tr>
<tr>
<td>Morbidity per cent.</td>
<td>74.02</td>
<td>80.74</td>
</tr>
<tr>
<td>Mortality per cent.</td>
<td>1.32</td>
<td>1.03</td>
</tr>
<tr>
<td>Average days of absence</td>
<td>13.89</td>
<td>13.84</td>
</tr>
<tr>
<td>For the whole staff</td>
<td>18.77</td>
<td>17.92</td>
</tr>
</tbody>
</table>

The days of absence increased from year to year; but there must be taken into consideration the influenza epidemic of 1918 and the influence of the war. In comparing the data for the period for 1904-1914 with that for the period 1914-1921, there is noted a diminution in the mortality rate; for the men 1.51 as compared with 1.03, and for the women 1.85 as opposed to 1.03.

Religious orders, which under the hospital organisation of Milan carry out the work of superintending in the hospitals but have very much longer hours than the nurses, have no annual leave and do not enjoy good living conditions (lodging, food, etc.), do not provide (and not without good reason) such accurate morbidity statistics as the other nursing services. Mortality data for these orders are however accurate. From 1914 to 1921 amongst 150 Sisters of Mercy there were 17 deaths (2.12 per cent.), 7 due to tuberculosis, 3 to influenza and 3 to broncho-pneumonia. From 1904 to 1913 there were amongst 107 Sisters of Mercy 18 deaths, 8 being due to tuberculosis and 4 to typhoid fever.

Italian mortality statistics for men over fifteen years of age and for the period 1915-1917 show the following figures (per hundred male deaths from all causes and for the same occupational class):

<table>
<thead>
<tr>
<th></th>
<th>1915</th>
<th>1916</th>
<th>1917</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typhoid fever</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All occupations</td>
<td>2.0</td>
<td>1.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Nurses</td>
<td>4.5</td>
<td>2.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Tuberculosis:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All occupations</td>
<td>8.4</td>
<td>8.8</td>
<td>8.8</td>
</tr>
<tr>
<td>Nurses</td>
<td>22.0</td>
<td>25.0</td>
<td>24.6</td>
</tr>
<tr>
<td>Diseases of the liver:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All occupations</td>
<td>1.7</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Nurses</td>
<td>2.3</td>
<td>2.8</td>
<td>5.4</td>
</tr>
</tbody>
</table>

The various causes of death reported by D'Este in Florence were as follows: gastrointestinal diseases due especially to irregular meals; diseases of the locomotor system; infectious diseases; respiratory diseases; traumas; occupational or otherwise, the former being five times as numerous as the latter; diseases of the nervous system, etc.

According to Chincarini the most frequently occurring diseases showed the following values (annual average per 100 persons):

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestive diseases</td>
<td>13.1</td>
<td>26.0</td>
</tr>
<tr>
<td>Gastro-enteritis</td>
<td>19.1</td>
<td>13.4</td>
</tr>
</tbody>
</table>
| Diseases of the locomo-
|   try system           | 7.3 | 9.1   |
| Respiratory diseases:  |     |       |
| Bronchitis             | 2.6 | 5.5   |
| Broncho-
|   pneumonia, etc.      | 1.3 | 3.0   |
| Tuberculosis           | 1.1 | 2.3   |
| Infectious troubles   |     |       |
| (excluding tubercu-
|   losis)               | 5.3 | 7.1   |
| Diseases of the heart  | 2.3 | 8.7   |
| and blood vessels      | 2.01| 5.5   |
| Diseases of the skin   | 5.3 | 7.1   |
| (eczema, whitlows, etc.) | 4.96 | 4.1  |
| Diseases of the sense organs | 2.1 | 6.4   |
| Diseases of the uro-
|   genital system       | 1.8 | 9.5   |
| Diseases of the ner-
|   vous system (neu-
|   ralgias, etc.)       | 11.0| 3.7   |
| Accidents              | 10.0| 3.3   |

In Germany Hamel found for nurses 0.27 cases of probable occupational infections per annum and per hundred exposed in the hospitals and 0.48 in the university clinics and 0.36 in tuberculosis sanatoria. The Protestant deaconesses presented a rate of 0.53, organised female nurses other than those belonging to religious orders 0.29 and female nurses not connected with any association a rate of 0.26.

Cornelius ascertained that of a nursing order of Sisters of Mercy, 61.9-73.8 per cent. died of tuberculosis between the ages of fifteen and fifty. In Prussia 39-43 per cent. of a nursing staff were found on examination to be tubercular, and in Munich 50 per cent. of the deaths of a hospital staff were due to tuberculosis. Official statistics for Bavaria, 1890-1908, published in 1913, show 56 per cent. of a certain order of nurses to have died of tuberculosis. Cornet and Von Maes are agreed, after detailed investigation of the subject, that tuberculosis is the predominant cause of mortality amongst nursing orders. Of 100 deaths amongst nursing sisters the following were due to tuberculosis:

<table>
<thead>
<tr>
<th></th>
<th>Per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sisters of Mercy (1863-1888)</td>
<td>61.9</td>
</tr>
<tr>
<td>Sisters of Borromean Order (1849-1918)</td>
<td>37.3</td>
</tr>
<tr>
<td>Deaconesses (1840-1914)</td>
<td>34.9</td>
</tr>
<tr>
<td>Organised nurses (1903-1914)</td>
<td>31.7</td>
</tr>
</tbody>
</table>
The rate for the female population over fifteen years of age in Prussia, 1897-1901, was, in contrast to these rates, 15.9. Kossisch found the tuberculosis rate for nurses in Bavaria three times as high as the average rate. On the other hand, the Imperial Health Office characterised rates for doctors and nurses in German hospitals, 1906-1911, as "not unduly high", but the issue of a circular containing measures for combating infections (Ministry of the Interior, 10 October 1920) seems in contradiction with this (for recommendations contained therein see below, Hygiene).

In France, Pissavy (1927) found that doctors belonging to the wards for tubercular patients in the Paris hospitals suffered from tuberculosis during the year 1926 to the extent of 8.8 per cent., whilst male and female nurses in the same wards were affected in the proportion of 3.3 per cent. In hospitals without special wards, Meerbeck, cited by Epstein, states that male and female nurses were affected respectively in the proportion of 3.6 and 1.5 per cent. The higher morbidity rate for students is probably due to the fact that in questioning and examining the patients they are more likely than the nursing staff to come within the zone of projections of virulent tubercular bacilli. Riet has confirmed the importance of position in regard to persons obliged to approach tubercular patients. Thus, for example, attendants on duty at the entrance to the Léon-Bourgeois Dispensary have on several occasions contracted tuberculosis from salivary projections from patients until a protecting screen was erected to prevent this. The same expert has also noted cases of tuberculosis amongst laboratory staff, who were too greatly overwhelmed with work to enable them to observe the necessary precautions in handling infected material.

Hamel has reported the tuberculosis morbidity rate amongst nurses to be as follows per annum per hundred exposed: 0.80 for male nurses in general hospitals; 1.07 for students; 0.42 for those in sanatoria for tubercular patients; 0.58 for Catholic nursing orders; 0.68 for those not belonging to any organised body.

Epstein states that half of the cases of tuberculous infection occurring in hospitals, one-third of those in university clinics and six-sevenths of those in special institutions for tuberculosis can be regarded as occupational infection. For Catholic orders, Storch, cited by Epstein, states that from January 1919 to August 1922, 319 out of 10,692 sisters died from tuberculosis or four times the number for Prussia in general.

According to Chincarini, tuberculosis is very frequent amongst nurses in the "Maggiore" Hospital in Milan. During the period 1914-1921 there were 129 victims, 97 of whom were women, and 23 deaths, 14 of these being women. Per cent. for women, 2.8 per cent. for men and 17.8 per 100 patients). The Hospital Committee in 1919 decided to provide free treatment to nurses affected with open tuberculosis of occupational origin without any limit as to duration and to grant paid leave of three years' duration, at the end of which a pension should be granted unless a cure has been effected.

Certain authorities ascribe the high death-rate to infection, while others incline to the view that the over-ambitious work in the religious orders and bad objective conditions are mainly responsible. Six cases of tuberculosis which occurred among nurses were attributed to insufficient training, inefficient installation for destroying sputum and to nursing of very bad cases.

Typhus infection is specially common in country hospitals and cases of infection caused by bath water have occurred frequently. Schäuber (in Zeitschr. der Hygiene. Infektionskrankheiten) states that 1,797 nurses developed typhus in treating 35,647 patients, or a ratio of 3.3 per cent. of nurses to patients.

A case of epidemic encephalitis affecting a nurse who had nursed a case of post-encephalitic Parkinson disease had been reported by Crouzon and Horowitz in 1929.

Syphilis infection. — Nurses and midwives are highly liable to syphilis infection from syphilitic patients and infants, which may be contracted in a multiple number of ways. Childbirth cases are responsible for the majority of infections.

Skin infections. — Amongst skin infections may be mentioned whitlows and carbuncles, while eczema may be contracted from the use of mercury sublimate. Even the solution of 1:1000 used may give rise to blisters and eczema. Catamin and sulphur ointments likewise cause obstinate eczema and danger is also presented by the use of creosote, lysol, chlorine, lyes and acids, and silver nitrate solutions. Burns are not uncommon in the course of sterilisation.

Female hospital staff not infrequently suffer from strain and displacements caused by lifting heavy patients and from dysmenorrhoea and kidney trouble. Nervous affections and neurasthenia are common among nurses due to overwork, nervous tension and night duty, and a tendency to seek relief in the use of drugs. Overheating in operating theatres, baths, etc., causes rheumatism and cases of pneumonia. Nurses are also exposed to the effects of chloroform and ether fumes in operating theatres, already referred to under "Doctors", and to danger from arsenic and mercury fumes in handling such preparations. It should be recalled here that nurses belonging to religious orders, especially missionaries, are, like military doctors, exposed to exotic diseases and to a higher sickness rate on account of defective hygienic conditions (climate, feeding, etc.).
Children's nurses. — In regard to infections contracted by children's nurses, the most important factor is the very close contact presenting additional risk to that involved in treating adult patients. Children's nurses are exposed to risk from syphilis (see above "Syphilis Infection"), pemphigus neonatorum, dermatitis exfoliativa, multiple skin carbuncle, impetigo contagiosa, pediculosis, pyoderma and blennorrhoea. The risk is greater in private nursing where hospital precautions and often elementary means of taking precautions are absent. Often too the nurses themselves are wholly ignorant of the danger or means of avoiding it.

Mycosis, herpes tonsurans and erysipelas may also be contracted and often the medicaments used present danger, i.e. potassium, hypermanganese baths. Stomatitis mercurialis may be derived from iodine and sublimate. Infectious maladies such as diphtheria, measles, whooping cough, scarlet fever, etc., and also vaccination infections, but adequate care offers protection against such infection. Children's nurses may become carriers (e.g. diphtheria germs) and constitute a danger for other charges.

Hygiene

There is no formula for the improvement of the health of physicians. The old rules of Fodére in great part are still valid, particularly his precepts that the physician approach his task without fear, that he avoid an excessive burden of work and that he secure adequate rest after his labours. Doubtless there is no single measure of so much value in the conservation of health as a periodic physical examination at the hands of an able and understanding physician. Ignorance of impending disease may be blissful, but in such circumstances wisdom cannot be folly.

A doctor should be physically fit for his work and his sense organs should be intact. There is required of him not only a very wide general culture, but he should at the same time possess what few doctors really do possess, the faculty of making a psychological study of his patients. Durig has, however, rightly stated that certain diseases and states of health should not be considered as sufficient for exclusion from the medical profession. It is in fact true, for instance, that a tubercular doctor can practice in sanatoria or on board ship, while there is nothing to prevent a lame man from practising as a dentist, or a doctor with a paralysed hand or suffering from shortsightedness from engaging in therapeutical treatment. An individual whose hearing is affected but whose sight is good may become a good surgeon, whilst a shortsighted doctor whose hearing is good may make an excellent physiologist. Whilst a practitioner in a mountainous district, for instance, must be in good health and capable of long and tiring walks, such qualities are not required of a medical scientist desirous of engaging in laboratory work or in the teaching profession.

All nurses and attendants in hospitals should wear practical uniform, including head-gear and ward shoes, and should be instructed in efficient methods of disinfection. Baths and washing facilities should be provided for the separation of those of the patients. Male attendants should be called upon for lifting heavy patients, mattresses, etc.

Better methods of selection in the nursing profession would, together with shorter regular hours and adequate medical supervision, greatly diminish the professional risk, and efforts should be made to impose regulation of hours and wearing of suitable uniform on all nurses, including those belonging to charitable and religious orders. Comfortable well-ventilated sleeping accommodation should be provided and where possible facilities for physical exercise and recreation.

The habit of dry sweeping in infection wards twice daily should be discontinued and cleaning by vacuum installed. As parasites often transmit infection by bites, dirty patients should be obliged to pass through a delousing station provided next to the reception ward before admission for treatment, and precautions should be taken to keep infection wards free from flies, mosquitoes, etc. All persons with open wounds or scratches should be rigorously excluded from all sources of infection — fever wards, operating theatres, anatomy rooms, etc., and notification of all cases of sepsis through this channel should be insisted on. Infectious material should be transported in specially adapted vessels filled with detachable washable metal linings and lids which should be promptly disinfected after use.

All personnel in contact with infectious cases should be thoroughly instructed in the requisite precautions to take and should be ween nourished and not overworked. Schemes of insurance providing for treatment and compensation should be instituted for staff exposed to infection.

The danger encountered in nursing tuberculosis patients is stated to be not above normal in other occupations.
when every precaution is taken. Patients with infected sputum should be isolated, and spitting receptacles disinfected or special receptacles adopted which permit of incineration. Pre-disposed persons should be rigorously excluded from all contact with tuberculosis. Nursing staff in contact with such cases should be very well fed and their occupation should whenever possible be changed after three months with return to tuberculosis nursing only after lapse of one year. Working hours should never exceed eight per day inclusive of rest intervals with weekly rest of thirty-six hours at least. All vessels should be thoroughly disinfected and sickrooms should be washed down regularly with fluid disinfectants. Wearing of practical uniform and changing of uniform when off duty should be compulsory. All staff should be thoroughly instructed in the danger to which they are exposed and in the requisite precautions. Above all, doctors and nurses chosen for work in sanatoria and hospitals where tuberculosis patients are treated should be thoroughly examined before taking up work and all doubtful subjects excluded, and those admitted periodically; examined thereafter and removed on the first sign of any symptoms.

The Circular, already referred to, circulated by the Ministry for the Interior (Germany, 10, October 1920) makes the following recommendations: separate wards for tubercular cases, exclusion from these of nurses of feeble constitution, previous tuberculosis cases or susceptible persons; all nurses employed to be medically examined and weighed at regular intervals and immediately removed as soon as unfavourable signs are shown, nurses to be taken off duty at once when sick and not readmitted till passed as fit by a doctor; thorough instruction of staff in dangers and precautionary measures and technique of disinfection; provision of nourishing food rich in fats and of messrooms and sleeping accommodation separate from patients; annual leave of at least four weeks in summer and opportunities for rest during intervals between working hours; well-trained and efficient staff to be employed exclusively for tuberculosis; staff to be transferred to other wards after certain time spent in the tubercular wards; special attention to be directed to isolation of tubercular and infectious cases in lunatic asylums.

This Circular was followed by Special Orders in Prussia (1920), Bavaria (1921), Baden, Hamburg, Brunswick, Oldenburg, Anhalt, Bremen, Lubeck, Mecklenburg-Strelitz, Waldeck and Schaumburg-Lippe.

Doctors and nurses in contact with syphilis and skin infections should have their hands protected by rubber gloves when using disinfectants, as strong disinfectant solutions destroy the skin and open a door to infection. More care should be devoted to the training of midwives and children's nurses who engage in private nursing, as the danger is much greater for such persons than for those engaged in medical institutions under good medical supervision. Here again the great importance of compulsory notification of all cases of infection must be emphasised.

Staff exposed to ether and chloroform fumes in operating theatres should have short spells of rest, and be thoroughly instructed in the danger to which they are exposed and the requisite precautions. Above all, doctors and nurses chosen for work in sanatoria, and hospitals where tuberculosis patients are treated should be thoroughly examined before taking up work and all doubtful subjects excluded, and those admitted periodically; examined thereafter and removed on the first sign of any symptoms.

LEGISLATION

Peripheral paralysis occurring amongst employees in chemists' and druggists' establishments, poisoning by arsenic, phosphorus or mercury, and pulmonary affections due to chemical drugs occurring amongst persons engaged in chemical laboratories are subject to compulsory notification in Holland. Infectious diseases occurring amongst nursing staffs are compensated in Western Australia; smallpox, cholera, tetanus, typhoid fever, diphtheria, plague, measles, mumps, scarlet fever amongst nursing staffs in hospitals in Queensland; in Austria infections occurring amongst the staff of scientific laboratories; and in Germany infections occurring amongst the staff of hospitals, asylums, maternity institutes, health services and scientific laboratories. Mercury poisoning in Russia. For legislation relative to röntgen rays, and radium, see articles "Röntgen Ray Operators", and "Radium and Radio-Active Substances".
MEDICAL INSPECTION OF FactORIES

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Dr. Wade Wright
New York.

Medical Inspection of Factories

French: Inspection médicale du travail.
German: Ärztliche Gewerbeaufsicht.
Italian: Ispezione medica del lavoro.
Spanish: Inspección médica del trabajo.

HISTORICAL

Austria was the first industrial country to organise technical factory inspection, promulgating towards the end of the eighteenth century (1786) a series of regulations for the protection of children employed in industry. The action taken was to entrust to the medical men of the district the application of the regulations, with a view to the prevention of illness among apprentices. In 1816 the Government of Lower Austria applied these regulations more rigorously; in 1842 the Chancellor elaborated a Bill on the employment of children, with the object of placing the control in the hands of local authorities, inspectors of local schools and the clergy. In 1869 an important Bill laid it down that inspectors of factories ought to be public officials, quite independent of the employers. This Bill failed, and successive efforts in 1876, 1877 and 1879 suffered the same fate. Thus factory inspection did not attain a legal status until the special Act of 17 June 1883, which remained in force up till 1921.

In Great Britain a Factory Act dates from as far back as 1802, when a law was passed of which the object was to "preserve the health and morals of apprentices and other persons" employed in spinning mills and other textile factories, as well as in cotton mills and other factories (Morals and Health Act, 1802). Its application was placed in the hands of the local authorities, and Justices of the Peace had the duty of selecting either from amongst themselves or ministers of religion persons who were ready to fill, in an honorary capacity, the functions of inspectors (visitors). If they considered that existing conditions were likely to promote the spread of infectious diseases, they could require that the employer should submit, at his own expense, to an enquiry carried out by a medical man, who was obliged to present to the inspector a report on his findings. This law was not observed in practice, and this necessitated successive amendments (1819, 1825, 1883) which led to the introduction of official factory inspection placed in the hands of inspectors who were in possession of sufficient power to accomplish their task. In view of
the numerous abuses arising from the question of fixing the age of admission to factory work, the inspectors would only recognise certificates of fitness given by medical men selected by themselves. This was the origin of the "certifying surgeon" who still plays an important part to-day in English factory legislation (see below).

Conditions of labour prejudicial to the health of the workers could be combated by the Sanitary Act of 1866, the application of which was placed in the hands of the local sanitary authorities. In 1857 clauses were introduced into the Factory Act bearing upon health, the supervision of which was placed in the hands of factory inspectors. Consequently, hygienic conditions in workshops properly so called came under the Public Health Act of 1875, which replaced the Sanitary Act of 1866, the question of the duration of employment alone remaining in the hands of the inspectors. This state of things continued until 1891, when supervision of measures affecting health and workpeople was again entrusted to the local authorities, the inspectors of factories only acting as a sort of "super-inspectorate". Finally, the Factory and Workshops Act of 1901 introduced the procedure as it exists to-day.

In France, the campaign started in 1820 by the Industrial Society of Mulhouse resulted in the initiation of the first law for regulating industry (1841). At the same time, the inspection instituted did not go as far as to subordinate the private interest of the employer to the public interest, as the question of safeguarding did not yet come within the powers of the police. A Bill passed in 1848 by the Upper Chamber proposed the appointment of salaried inspectors to carry out the regulations concerning employment of children in factories, but it was not until the year 1868 that an Imperial Decree imposed this duty on the mines engineers. In 1870 the Government introduced a law in the Senate for the creation of four posts as superintending inspectors and sixteen divisional inspectors. In 1874 a law on the employment of children and female young persons in industry widened the circle of persons under supervision, strengthened protection relating to hours of work and prescribed various measures for the protection of the life and health of the workers. Finally, provisions contained in the laws of 2 June 1892, 12 June 1893 and 9 April 1898 enabled the inspector to intervene in case of factory accidents and led to the organisation of factory inspection as it exists to-day.

In Germany factory inspection has been organised in the different States independently of one another. Prussia was the first to create such an inspectorate. In 1824 the Minister invited the prefects to report to him on the employment of children in the Rhine provinces, about which he had received disquieting reports since 1818. Consequently on this invitation, the Prefect of Düsseldorf proposed the institution of local committees of inspectors (1835), which was followed in 1837, on the initiative of a Rhineland employer, by a proposal to create a regular service of factory inspection. These measures led in 1859 to the adoption of regulations as to the employment of children in factories, the results of which were not too satisfactory. However, the adoption in 1869 of the Industrial Code (Gewerbeordnung) marked a real progress in the development of Prussian and German factory inspection. Later amendments modifying this Industrial Code brought organisation in Germany up to the point where it stands to-day.

In Belgium the origin of protection for the workers dates back as far as the era of Napoleonic domination (1810), when a law prescribed that officials should inspect mines, foundries and similar undertakings. Royal Decrees of 1849 and 1863 subjected dangerous and unhealthy establishments to regulations intended to impede or diminish ill-effects from such establishments, inconveniencing people in the neighbourhood as well as the workers themselves. A Decree of 27 December 1866 required that, if these measures, the execution of which was in the hands of the administrative authorities, be made more stringent and efficacious. Nevertheless, the basic law for inspection of factories was not adopted until 5 May 1888; this provided for the inspection of dangerous, unhealthy or offensive establishments, the supervision of machinery and boilers, and the right of inspectors to enter any factory, etc. A Royal Decree of 1895 prescribed the re-organisation of factory inspection and classification and established measures which are, in the main, still in force at present.

In Switzerland the first law for the protection of workmen was promulgated in 1815 by the Canton of Zurich, but it remained ineffective. Effective inspection of factories for the whole of the Confederation was not provided
for until 1877, as a result of a Federal law for all factories.

In the Netherlands, as a result of a parliamentary enquiry in 1886, a law relative to labour, which provided for the appointment of factory inspectors, was adopted on 5 May 1886. This law was completed by the law on industrial safety of which the most recent form dates back to 1915, and which contains provisions relating to conditions of hygiene in workshops and the prevention of industrial diseases.

In Italy the conception of factory inspection as a public service is only of recent origin, as its organisation dates back to 1912. However, as in other countries, various legislative measures had already assured a control over the employment of children (1886), factory accidents (1898), etc.

Amongst other countries possessing relatively long-established inspection services should be mentioned: Denmark (1832, 1851); Sweden (1889); Finland (1832, 1868 and 1873); Spain (1873); as well as the United States of America (Massachusetts: 1842, 1852; Pennsylvania: 1827, 1848; Connecticut and Maine: 1836, 1852; New York State; 1886; etc.).

The Medical Inspection Service

While factory inspection in the beginning was, in certain countries, placed in the hands of persons who, besides a certain amount of instruction possessed also much tact and good sense, and in other countries was given over exclusively to engineers to emphasise the technical nature of the service, the need had nevertheless been early realised for calling in aid the collaboration of the medical profession in all questions relating to hygiene and the health of the workers. This necessity was felt by most industrial countries and resulted in the organisation of medical services.

The medical inspection department in Australia comprises a Divisional Director of industrial hygiene, a medical adviser attached to the head office and a Chief Medical Inspector for each State. These last positions are not yet filled, but at the present moment two medical inspectors are attached to a clinic in the mining district of Broken Hill.

In Austria factory inspection has comprised, since 1919, a medical department, directed at the moment by a woman. As an official factory inspector, she has the right of entry into factories and workshops, and into the workers’ homes where home work is carried on, places where apprentices are employed, workers’ dwellings, etc. Mines, railways and agricultural undertakings are outside the scope of her duties, and in most cases she makes her visit to unhealthy establishments in conjunction with the factory inspector. The work of the medical inspector forms a special report which appears in the annual report on factory inspection.

In Belgium the medical inspection of factories includes a central department and a provincial department; the former, which is vested with full authority, directs the latter, and is under a Chief Inspector of the department and three medical inspectors, one of whom is a woman, and one an inspector holding a doctor’s degree in science and chemistry. A laboratory for chemical and biological research is attached to the central department. The provincial department comprises nine inspectorial districts, one for each province, each district being under the control of a medical inspector. The supervision of some of the districts is in the hands of certain medical inspectors who are officials of the central office. The duties of members of the medical inspection department are as follows:

1. to organise the protection of pregnant women and nursing mothers in industry;
2. to ensure the protection of the health of apprentices from fourteen to eighteen years old, and to assist in their vocational guidance;
3. to study all branches of industrial physiology and pathology;
4. to bring their special knowledge to bear on all social services;
5. to spread throughout the industrial world a knowledge of the best methods for preventing occupational disease and to promote the use of the most rational health measures;
6. to supervise the application of the official medical regulations.

Performance of the medical inspector’s duties is assured by various legal provisions concerning health and safety of the worker (physical cleanliness, first-aid, smallpox vaccination, etc.).

The medical inspectors of factories can enter freely during the day and night premises under their supervision; they can conduct prosecutions for infringements of the law and may ap-
Medical inspection of factories.

In the course of their visits they make useful suggestions to the employer, but definite instructions must be addressed to the employer through the district inspector of factories, who alone possesses the right of taking definite action. The medical inspectors may be requested to investigate certain questions or to collaborate in regard to enquiries made by the Federal Office of Hygiene. They act on occasion as medical advisers to the Prussian or Federal Ministry on questions of industrial hygiene. They collaborate with insurance offices, with a view to improving sickness statistics, besides giving talks to medical men with the object of disseminating knowledge of industrial hygiene. They deal with vocational guidance. They may not practise or act as consultants for social insurance services except

In France, a medical inspection service has not so far been established. However, during the war, a special branch comprising medical men had the task of informing the Ministry of Munitions as to conditions of health and safety of the workers, and the organisation of labour. Furthermore, during the war, a member of the Superior Public Health Council of France was entrusted by the Consultative Committee on Labour and the Committee on Women's Labour with the examination of the hygienic measures taken or to be taken to safeguard the personnel, and particularly the women employed, against the risks inherent in the different manufacturing processes.

In Germany medical inspection was organised separately in the various States. A service instituted in Prussia in 1921 comprises five industrial physicians (Landesgeverbeärzte) resident respectively at Dorpat, Berlin, Wiesbaden, Erfurt and Breslau, under the authority of the Minister of Social Services. They have to collaborate with governmental and industrial councils in the districts under their charge; they are naturally in close contact with the other factory inspectors, as well as medical practitioners in the district. They have the right of visiting factories, but they are generally required to give notice to the Government department or occupier beforehand, in order to allow them to take part in the visit. They have not the right to draw up regulations, but when there is a difference of opinion between them and the departmental councils and the occupiers on special points, they can be summoned before the President of the district affected or even the Ministry.

The duties of the medical inspectors are:

(a) to advise and assist the factory inspectors and mines inspectors on questions of industrial hygiene;

(b) to study the morbid changes occurring among the workers in their relation to the work effected, methods of prevention and cure of such changes, as well as all questions of industrial hygiene affecting the health of the workers.

In practice their activity is organised in such a way that they are informed by the Sickness Insurance Offices and the workers' organisations of the occurrence of sickness or other industrial injury affecting the health of the workers. Owing to the compulsory notification of certain industrial diseases, brought into line with accidents and the collaboration of technical inspectors, they are kept well informed in regard to all aspects of health and sanitary conditions in industry. In the course of their visits they make useful suggestions to the employer, but definite instructions must be addressed to the employer through the district inspector of factories, who alone possesses the right of taking definite action. The medical inspectors may be requested to investigate certain questions or to collaborate in regard to enquiries made by the Federal Office of Hygiene. They act on occasion as medical advisers to the Prussian or Federal Ministry on questions of industrial hygiene. They collaborate with insurance offices, with a view to improving sickness statistics, besides giving talks to medical men with the object of disseminating knowledge of industrial hygiene. They deal with vocational guidance. They may not practise or act as consultants for social insurance services except

In Brazil the regulations of 5 May 1923 lay down that the medical factory service shall consist of a Chief Inspector and an adequate number of factory inspectors or sub-inspectors.

In Canada an industrial hygiene department carries on its functions under the Ministry of Health, Toronto.

In Finland a Resolution of the State Council of 1927 formed a medical factory inspection service.

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when requested by a superior authority. Their activities are recorded in an annual report which is published separately from that of the factory inspectors.

In Bavaria, the position of medical inspector of factories (Landesgesetzeberaetsl) was created in 1908, as a result of the insistent demand from representatives of the working classes and of the medical profession. The medical inspector, who acts under the Chief Inspector, co-operates with technical inspectors and mines inspectors, and is in touch with the medical practitioners in the district, etc.

His duties include the following:

1. acting as referee; giving advice to factory and mines inspectors; making surveys for the Ministers of State, the above-mentioned officials and the higher insurance tribunals;
2. visiting industrial undertakings and mines with a view to inquiring into varying conditions of work and arrangement of plant, studying different methods of work, medically examining the workmen, conducting research into hygienic conditions, etc. ;
3. controlling the activities of the examining surgeons;
4. supervising first-aid provisions;
5. scientific work; making health studies of certain occupational groups doing statistical and clinical research, both in the laboratory and in every department of industrial medicine;
6. preparing reports (literature, etc., on the subject, etc.);
7. doing propaganda work and giving instruction by means of articles in the press, lectures in the Universities and in the higher technical schools, reports to medical societies;
8. organising and maintaining the Social Hygiene Section in the Bavarian Social Museum;
9. studying the various problems of social hygiene which affect the working classes: alcoholism, housing, tuberculosis, and food problems, etc. ;
10. centralising the reports of cases of industrial diseases compulsorily notifiable and elaboration of this material.

In Saxony, the occasional collaboration of the medical practitioners of the district, often impossible without loss of time, was completed by the appointment of a physician attached to the Ministry of Labour and Social Services, and co-operating with the Chief Inspector of Factories. On the other hand, as a result of provisions made by an Ordinance of 12 October 1921, which requires factory inspectors to have a knowledge of economic and medical questions, the medical inspectors have been able to exercise the functions of factory inspectors. In practice, the administrative authorities, in distributing the work, utilise to the greatest extent possible the special capabilities of the medical inspectors, whose essential work consists in supervising the practical application of measures protecting the health of the workers in general. Their activity is particularly concerned with the study of occupational diseases and other injuries to health, the medical examination of particular groups of workers, the effects of certain methods of working, and the peculiar hygienic questions relating to recently-discovered products or methods of production. Besides this, the medical inspectors supervise the work of the factory surgeons and give them any advice calculated to aid them in carrying out their duties and in the study of plans for construction or alteration of industrial establishments, etc.

In the State of Baden, the medical inspector, in conjunction with the superintending inspectors, supervises factories where unhealthy work is carried on. The inspection of mines is independent of factory inspection, but all questions of hygiene are referred to the medical inspector. Like the heads of the other inspection departments, this official is directly responsible to the Ministry. He compiles a special annual report on industrial hygiene, which forms part of the general report on factory inspection. In addition he gives lectures on questions of industrial hygiene, finishing courses for the benefit of medical officers and, in the higher technical schools, courses for the benefit of young engineers.

In Great Britain, towards 1831, when the age of admission of children to factories was first fixed in the textile industries, the service of the "certifying factory surgeon" was first brought into existence.

At present medical inspection of factories in Great Britain is included in the factory department of the Home Office, in which the medical inspectors form an integral part of the general
factory inspectorate, consisting of a Chief Inspector, three deputy chief inspectors, a Senior Medical Inspector and four other medical inspectors (of which one is a woman).

Appointments for medical inspectors are first advertised and then a selection is made, after scrutiny of medical qualifications and previous experience, of a certain number of candidates for interview and final selection. The services of the medical inspectors are, as far as the small number will allow, assigned divisionally, that is, at London (covering the South Eastern, Western, Midland and Eastern Divisions); Manchester (covering North Western, East Lancashire, North Eastern and North Midland); Glasgow (covering Scotland, Newcastle and Gateshead Divisions); and the woman inspector in London (covering the Southern Division). While thus assigned to divisions, if one inspector has special knowledge of a particular branch of industrial hygiene (e.g. silicosis and pneumoconiosis) he is commissioned to visit the other divisions occasion arises.

The medical inspector's duties and powers are in general identical with those of other inspectors of factories. They include particularly: (1) supervision of the work of certifying factory surgeons and appointed surgeons, whose duties are mentioned later; (2) special enquiries into dangerous and unhealthy industries; (3) inspection of works under regulations made by the Home Office under the Factory Act, particularly those enforcing periodic medical examination, and Orders relative to Welfare made under the Police, Factories (Miscellaneous Provisions) Act, 1916; (4) all questions concerning injury to health of workers; (5) supervision of first aid in factories; (6) drafting of new regulations required after enquiry dealing with dangerous and unhealthy industries.

The Factory and Workshop Act, 1901, gave the medical inspectors the right of prosecution, but in practice this is promoted by the factory inspector of the district concerned, the medical inspector only attending as witness.

The certifying factory surgeons, to whom reference has been made above, number some 1,800 and are distributed over the country, one for each district, like the public health officers. Their duties are: to examine young persons of from fourteen to sixteen years of age before employment in factories. They have the power of attaching conditions as to the nature of the work on which the young persons may be employed. Further, they make periodic medical examination of the workers in certain dangerous and unhealthy industries. They report on all cases of industrial poisoning which are notifiable under the Factory Act. Lastly, they grant certificates entitling to compensation in the case of industrial diseases scheduled under the Workmen's Compensation Act. The certifying factory surgeons are appointed by the Chief Inspector of Factories. The duties of the appointed surgeons, of whom the number is very limited, are to examine periodically persons employed in certain dangerous and unhealthy industries under regulations, taking the place of the certifying factory surgeon. Appointed surgeons are selected by occupiers, and their appointment made subject to the approval of the Chief Inspector of Factories.

Further medical services are rendered by:

(a) a special bacteriologist, for the purpose of examining samples of wool and hair for the presence of anthrax;

(b) a specialist chemist for the purpose of research work;

(c) the Government Laboratory, in assisting in chemical analyses;

(d) independent medical officers of health, appointed by county councils, and all local authorities carrying out subsidiary duties as to sanitation of workshops, the administration of the Factory Act in respect of sanitation in them being delegated to the local authority by the Factory and Workshop Act.

No special training for medical inspectors or certifying surgeons is provided at the Universities or elsewhere. Classes are held at London and Manchester Universities during one session on factory hygiene, as part of the course for the Diploma of Public Health, and are open to all fully-qualified medical practitioners. When confronted with difficult questions, the department can have them investigated fully by means of committees. Apart from this, much valuable aid is rendered by a permanent committee (Consultative Committee on Scientific and Industrial Research to the Privy Council) and, as need requires, by the Industrial Health Research Board (formerly the Industrial Fatigue Research Board.)

In Italy, medical inspection is entrusted to medical men with a status similar to that of the technical in-
spectors. Their main duties are:
(a) to ensure the enforcement of all Acts concerning labour and social welfare in industrial and commercial undertakings, offices, agriculture, and, in general, in all localities where work is carried on for wages or salary (the inspection of mines, quarries and peat cutting is carried out by the special body of mining inspectors), and (b) to collect all information and data concerning technical and hygienic conditions in industry, and also concerning the development of the national production and in general all information requested by the Ministry on the subject of industry or labour.

The medical inspectors have the same duties as all other technical inspectors, but they form a special body, ranking as a department, the chief of which resides at Rome and is attached directly to the Ministry of Corporations.

The other medical men are attached to the administrative head of the district in which they work and they can be attached to the service of the Chief Medical Inspector for the purpose of carrying out all duties in connection with the supervision of hygienic and sanitary measures.

The Chief Medical Inspector is entrusted with the duty of co-ordinating and directing all measures for the enforcement of hygienic and sanitary regulations, of giving his views on concessions and measures for the enforcement of such general principles, of carrying out inspections in agreement with the local inspectors in the relative districts, of conducting enquiries into conditions of industrial hygiene and health, and of carrying out any other work which may be assigned to him by the Minister. For the better accomplishment of these duties the Chief Medical Inspector possesses a chemico-physical research and bacteriological laboratory, etc. He may also be authorised to utilise other scientific laboratories for special research work, etc.

His work in supervising hygienic and sanitary conditions of labour is to a large extent assisted by the other sanitary officials in the municipalities.

In Japan, a medical director and three other medical inspectors constitute the staff at the Ministry of Labour headquarters, and there are about sixty regional medical men in different parts of the country.

In Lithuania, medical inspection of factories was organised in 1925.

In Mexico, a department of Social Welfare and Industrial Hygiene acts in conjunction with the Ministry of Industry and Labour.

In the Netherlands, the Chief Medical Officer and five medical men constitute the Central Inspectorate, which is under the Ministry of Labour, Commerce and Industry. These medical men are in the closest contact with the other factory inspectors on all questions relating to hygiene, in order to give them the benefit of their advice and support in giving effect to the provisions of the Factory Acts and Regulations. It is, moreover, their duty to report to the Chief Medical Inspector especially on matters which do not concern the district inspectors.

The Chief Medical Officer acts as the medical expert for the Ministry of Labour, the General Director, and the district chiefs.

The duties of the medical inspectors include inspecting factories, periodic medical examination of workpeople, as well as examination on commencing employment, in certain industries, collection of information on the frequency of occupational diseases, the organisation of first-aid, etc.

In Norway, the medical inspectorate comprises one doctor attached to the Central Inspection Department and medical men attached to the regional staff. The local departments are under the control of divisional inspectors appointed by the State.

In Peru, questions concerning the medical inspection of factories are dealt with by the Department of Industrial Hygiene, which exists in connection with the Ministry of Labour.

In Poland, there is a Central Medical Inspector of Factories, two medical men in the provinces and ten doctors attached to the National Sickness Fund, who are entrusted with the sanitary supervision of workpeople.

In Portugal, the department of Inspection of Factory Hygiene was re-organised in 1927.

In Sweden, there is a central department for Medical Inspection of Factories, with a Chief Medical Inspector; the technical inspectors have further the right of calling in provincial medical men on certain points.

In Switzerland, since the initiation of factory inspection, although there is no special service, medical men may become inspectors. Further, the medical officers of factories, in order to

1 The Chief Inspector of Factories happens at the moment to be a medical man, so that at present there is no doctor attached to the Central Office.
be independent of the employers, are paid by the State, which collects a tax paid by the employers on a basis of the number employed. Lastly, whenever occasion calls for it, resort is had to an expert i.e. a professor of a University (an authority on hygiene or forensic medicine.)

In the U. S. S. R. a Medical Inspectorate for Factories has existed since 1919 attached to the governmental sections of the People's Commissariat and having as its object the task of controlling hygienic and sanitary conditions in industry. Medical inspectors are completely independent of the technical inspectors in everything within their competence. Prosecutions, however, for non-observance of regulations cannot be instituted by medical inspectors, but only through factory inspectors. The duties of the medical inspectors are, among others:

(1) to carry out general investigations, where possible, on the conditions of work affecting health; to compile all scientific, statistical or other information, of use in a systematic effort to combat occupational diseases;

(2) to organise and apply measures of hygienic improvement of production and of conditions and methods of work;

(3) to supervise the execution of legal regulations in the field of industrial hygiene and prevention of accidents.

The medical inspectors have the duty of visiting the various factories, warehouses, etc., either of their own accord or at the request of the factory inspector or the workers' organisations. Professional training of medical inspectors is given in the Universities, all of which provide a compulsory course in industrial hygiene.

Up to the present, it has been principally a question of the appointment of medical inspectors of factories working in conjunction with technical inspectors. But in order to make such health supervision really general and effective, it is necessary to have a large number of co-workers, like the certifying surgeons in England and the appointed surgeons in Belgium, to assist the medical inspectors in their work.

For this reason the Central Labour Organisation would require to have peripheral branches functioning in the various districts. These district organisations could carry out duties which the central office never becomes acquainted with and, at the same time, effect the health work already assigned to the communes as regards industrial hygiene.

In the United States Medical Factory Inspection Services have been organised in several States (New York, Massachusetts, California, Ohio, etc.).

Ranelletti has insisted several times on the efficacy of municipal health offices in the principal municipalities, and he outlines the work of the medical factory inspectors as follows:

(1) Better organisation of the health service for granting certificates of fitness for admission to work of young persons of both sexes, and organisation of the medical department of vocational guidance.

(2) Compulsory periodic medical examination of persons engaged in unhealthy and dangerous industries and in industries where food is prepared.

(3) Collecting and filing information regarding hygienic and sanitary conditions of labour.

(4) Statistics of morbidity and mortality in relation to industry.

(5) Hygiene of factories and supervision of the application of regulations.

(6) Supervision of hygienic conditions, especially among home workers.

(7) Health education of the workers.

(8) Medical, social and charitable organisation work in the field of industry.

To sum up, the duties of the Medical Inspector can be classed under three main heads as follows:

I. — Duties concerning the Factories and Workshops

(a) Examination of plans for building or alterations in the factory.

(b) Right of inspecting the installation, transformation or method of working in any industry or trade.

(c) Right of entry and inspection in industrial undertakings.

(d) Supervision of the application of legislative measures in unhealthy industries.

(e) Investigation of health conditions in factories.

II. — Duties concerning the Workpeople

(a) Examination of young persons entering on employment.

(b) Examination of workers before commencing employment in certain processes.

(c) Periodic examination of children or young persons.
Men of Letters, Speakers, etc.

French: Gens de lettres, orateurs, etc. — German: Schriftsteller, Redner usw. — Italian: Letterati, oratori, etc. — Spanish: Escritores, Oradores.

HYGIENE AND PATHOLOGY

The occupation of literary men, or of those following other similar artistic professions (artists, literary, savants, philosophers, barristers, judges, etc.), or again that of public speakers, involves work demanding intense intellectual activity and personal sensibility. Those engaged in such work use up great stores of nervous energy, and draw on their resources to the point of exhaustion. Characteristic of such work is the fact that the nervous system dominates entirely the organic functions. Obviously, therefore, the health of individuals devoting themselves to work of this kind is put to a severe test, and is likely to suffer in the absence of attention to the principles of hygiene.

On the basis of the axiom that a sound mind can only exist in a sound body, it is evident that the physical health of literary men and orators is of pre-eminent interest to the hygienist. In the present state of knowledge and with the ordinary methods available, it is impossible to estimate the expenditure of energy entailed in intellectual work. It may be that there is merely some qualitative change in metabolism which is not reflected in any corresponding modification in the balance of metabolism. This view has led a number of authorities to consider that brain workers do not require such liberal and substantial food rations as manual workers, whose muscular expenditure of force demands considerable quantitative replenishment. However that may be, the contrary has often proved to be the case as might be instanced from the lives of many great writers.

It is true that abundant and heavy feeding by a person engaged in a sedentary occupation engenders troubles commonly known under the name of retarded nutrition, resulting in rheumatism, gout, gravel, arterioskerosis, etc. As a matter of principle, literary workers, in view of their sedentary occupation, are well recommended to confine themselves to a light well-balanced diet, limiting themselves to one principal meal in the day, preferably at midday and followed when possible by exercise to aid digestion. Goethe, for instance, in the effort to maintain his health found that it

(d) Periodic examination of persons employed in unhealthy industries and supervision of conditions under which work is carried on.

(e) Protection of expectant or nursing mothers.

(f) Collaboration with the technical department and the social welfare service.

(g) Vocational guidance and especially study of the physiological demands made by different occupations.

III. — Duties concerning Questions of Organisation and Scientific Enquiry

(a) Study of problems of industrial physiology, research into the causes and effects of occupational diseases and poisonings, and measures for their prevention; forming up scientific progress in the field of industrial medicine.

(b) Study of the best measures for organisation of a medical service in factories.

(c) Advice as to the classification of unhealthy undertakings.

(d) Participation in the drawing up of regulations for industrial hygiene and in the work of departmental committees on industry and hygiene.

(e) Participation in the evaluation of incapacity due to accidents at work.

(f) Collaboration in the drawing up of safety codes and propaganda brochures relative to measures of safety in industry.

(g) Collaboration in the preparation of annual reports.

(h) Propaganda with a view to disseminating throughout the industrial world knowledge of the most effective methods of prevention and the adoption of rational health measures.

(i) Official or unofficial collaboration with Universities, Insurance Funds, School Medical Inspection Services and other institutions interested in industrial medicine and hygiene.

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Prof. A. Ranelletti

(Rome)
suited him to reduce progressively his diet (Michelet). It would seem that intellectual work is not generally conducive to obesity, as is borne out by a long list of names of immortal fame, amongst whom may be cited Demosthenes amongst orators; Leon-Baptist Alberti and Leonardo amongst painters; Beethoven, Chopin, Verdi, Donizetti and Bellini amongst music composers; and from Dante, "of spare build ", to many later famous men of letters. Naturally, however, many exceptions occur since allowance must be made for differences in temperament and constitution. Thus for a subject of retarded nutrition with a tendency to stoutness severe dieting and regular gymnastic exercise may be advantageous. On the other hand, an individual with accelerated nutritional activity (hyperthyroidians, etc.) may be the better for plenty of food and rest after meals. Exercise is, however, generally to be recommended for intellectual workers, who are only too inclined to eschew it and seldom get sufficient opportunity for walking.

The question of the consumption of alcohol in relation to the performance of intellectual work has been much discussed. Alcohol is at present still regarded as a stimulant of the psychical functions and the consumption of drinks containing it in larger or lesser quantity is only too frequently resorted to by those engaged in literary work. Nevertheless, against a long list of men of genius known to have overindulged in alcohol and to have produced their work under its stimulus, must be placed the names of other equally famous men who abstained from its use. It may be argued that the conclusion may be drawn that the brain worker, be he a man of letters or a poet, may very well dispense with alcohol.

Without referring to drug addicts, who have used the most varied substances as excitants, it is useful perhaps to refer in passing to the abuse of coffee indulged in by some writers, certain of whom could not work without the aid of this stimulant. Nevertheless, mental effort should not depend on excitation, since every form of excitement is in the long run exhausting; the necessity being rather for perfect equilibrium since intellectual power is at its maximum under this condition (E. Mouton).

Tobacco smoking is much indulged in by men of letters and to cite only a few great names, Flaubert, Byron, Musset, Racine, Marquis de Sade, Voltaire, etc. were great smokers, though others, such as Victor Hugo, St. Beuve, Heinrich Heine, and above all Goethe, never indulged in the habit. In the opinion of these writers, tobacco did more harm than good, "transforming thought into reverie " (V. Hugo), "clogging activity" (Barbey d'Aurevilly), and has even been characterised as "a murderous pastime, a cruel desire, insatiable and useless" (Theodore de Banville).

So far as concerns the bodily health of mental workers, too much insistence cannot be laid on the value of cold baths, douche baths, etc., which are excellent stimulants.

As regards clothing, it should be comfortable and unconstricted. A writer seated in front of his desk should not, for instance, be hampered by tight, heavy or hot clothing likely to hinder the circulation and cause congestion. Balzac was accustomed to wear a monk's cassock while working, which he found to be thoroughly practical.

The above also applies to oratorical speakers whose work of meditation and preparation is similar to the work of the writer. During public speaking, however, they are obliged to submit to the constraint of clothing which may involve much discomfort.

Besides physical hygiene, men of letters ought to observe principles of intellectual and moral hygiene.

Various expedients have been followed by men of genius, such as reading aloud or declaiming with a view to stimulation of ideas. As regards hours of work no general rule can of course be laid down for such workers. In large towns, as is well known, writers prefer to work at night in the absence of noise and agitation. This may not be an unwise procedure provided undue fatigue is prevented by an adequate compensating period of sleep, provided always that night work does not prove detrimental to the eyesight. The greatest care must be paid to the prevention of ocular fatigue, and it is probably lack of attention to this which brought on blindness in the case of such great men as Milton, Montesquieu, Augustin and Thierry.

Mention should be made of the occupational affection of writer's cramp, from which certain authors have suffered in the production of their works in manuscript.

The introduction of rest periods or interruption of work has been recommended as effective in increasing efficiency in intellectual work. Nevertheless, many authors maintain, as against this view, that in the effort of producing something original, the spell may be broken by an ill-timed interruption. In the case of the majority of writers, the impulse to write is destroyed and its resumption de-
MEN OF LETTERS, SPEAKERS, ETC. — 294 —

Doses a long period of fastidious and sterile effort.

The problem of what attitude assumed by literary men while at work is the most favourable, does not admit of a uniform solution. It is well known that all varieties of attitude from agitated pacing up and down to a peaceful recumbent position have been favoured by different writers. Victor Hugo walked up and down whilst composing his poems and Mistral composed his whilst taking walks. On the other hand, Descartes, Leibnitz and numerous writers of delicate constitution preferred to work in a recumbent position.

Noise is one of the worst enemies of the literary man. Even here, however, exceptions are numerous and certain writers are known to have produced their best work in the chatter of taverns and to have been depressed by solitude (Théophile Gautier), while some like Verlaine courted the stir and tumult found in cafés.

It is an undoubted fact that the rigorous practice of the laws of hygiene must meet with abundant obstacles in the case of literary workers. In the first place, individual variations in will-power and particular attitudes of mind must always be taken into account. Efforts to regulate hours of work or output must remain Utopian measures in a domain where a man's work is the expression par excellence of personal talent. Another consideration to be taken into account is the social status of the writer. Many men of genius have been Bohemians, undisciplined individuals only capable of working under special environmental conditions (in which they are accustomed), however detrimental, and the suppression of which might involve banishment of inspiration. Since literature must be free from all constraint, it is obvious that all individuals, even those differing from normal standards, have the right of authorship.

Early writers in medical literature have devoted chapters to the enunciation of rules for mental work under hygienic conditions, stipulating intermittent activity and rest periods. Yet it would be highly ridiculous for a medical man to prescribe for a writer the time during which he should exert himself and when he should rest. Such advice cannot be taken seriously since it is impracticable, the creative spirit being by its nature free. "It would be a mistake to measure verve by a compass, to try to estimate enthusiasm or dose inspiration" (Réveillé-Parise). Rest and work cannot well be regulated except in accordance with the habitual disposition of each individual, since

the rule of hygiene which is perhaps the most important to observe in sustaining activity and intelligence is the entire liberty of this same intelligence.

So far as relates to the pathology of men of letters, their maladies are caused for the most part by the conditions under which they work. Certain authorities are of the opinion that intense intellectual activity strains the organ of thought and in proof of this quote many instances of writers and speakers who have been the victims of cerebral arteriosclerosis and its sequellae (cerebral haemorrhage, embolism, etc.—Copernicus, Malpighi, Linnaeus, Spallanzani, La Bruyère, Daubenton, Monge, Cabanis, Corvisart and others died of apoplexy (Layet). Without doubt, associated with neuro-muscular fatigue there is also the problem of mental fatigue. Discussion of this will here be confined to mention of the very interesting and original studies of Patrizi on mental fatigue, which he studied amongst speakers and intellectual workers. It is sufficient to state that his studies led him to adopt the view that there exist various individual types distinguishable by their manner of working and by their reactions to fatigue.

Yet, as Gley says, it is essential to avoid confusion in this relation between mental and cerebral fatigue. It is extremely difficult to admit of the possibility of cerebral fatigue because, as the French psychologist says, "the brain is the most complete organ; it is so to speak perfect, it never tires. Men who are accustomed to intellectual activity and who have worked all their lives can often continue work up to the most advanced age, retaining all their mental alertness and cerebral capacity in quite a remarkable degree. How many examples might be quoted! I do not therefore believe in cerebral fatigue properly so called. An individual, sound in body and mind, can work and work effectively until an advanced age and his intellectual output scarcely falls short in value of that shown at the height of his power. But there is such a thing as nervous fatigue especially one of sensorial origin. The sense organs become tired and the central organs (the cerebrum) from which sensations emanate, may be affected by this fatigue of the sense organs.

The sedentary life, a habitual sitting posture, work in a vitiated atmosphere, late and long nights, an unhealthy mode of living and solitude all combine to cause digestive derangement,
retarded nutrition, respiratory affections, nervous fatigue and a state of psychical disequilibrium. Digestive troubles often take the form of gout or gravel, amongst those who have suffered from calculi being Amyot, Erasmus, Calvin, Bacon, Leibnitz, Bos- suet, Newton, D'Alembert, Buffon, Voltaire, etc. (Civiale).

Amongst speakers laryngeal affections are of common occurrence: laryngitis and granular sore throat (inflammation, hoarseness, loss of voice), loss of the power of speech (Jaccoud, Krébier), laryngeal and pharyngeal phthisis, which have come to be regarded as more or less occupational maladies ("clergyman's throat"). Although phthisis cannot really be said to be an occupational disease in this connection, it is nevertheless considered as one to which professions demanding great vocal effort predispose, and at times it first manifests itself after a more than usually strenuous vocal effort (Gueneau, Mussy). A state of pulmonary congestion, at times accompanied by considerable haemorrhage, is paramount, each individual being animated with the urge to stamp his life with the seal of his own personality.

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Mental Hygiene in Industry


Industrial mental hygiene may be defined as that branch of industrial medicine which has for its object to safeguard the moral and intellectual health of the worker. Every factory surgeon practises mental hygiene in a more less conscious way, and often under some sort of cover, for whereas in daily practice the workers accept the help of the doctor in the treatment of physical ailments, they become suspicious as soon as it is a question of examining or protecting the state of health of their minds.

It is certainly in the interest of a firm to pay attention to the mental attitude of the worker with regard to his work, to absenteeism and to waste of time due to causes of a psychic nature, to the problem of fatigue caused by non-adaptation to environment, and to monotony associated with industrial work.

To submit the human body to work on machinery without taking into consideration the elements which characterise the living entity can only have injurious results, and certainly leads to waste of human material, which is as costly to the efficient working of a factory as it is to society.

Modern methods lessen more and more the quantitative importance of the human factor, which may fall as low as 1.9 per cent. in the instance of weaving cotton by automatic machines (Wyatt). Findings
MENTAL HYGIENE IN INDUSTRY

of this kind may give satisfaction to factory owners who are inclined to estimate values according to figures; but, as Buyse has observed, whatever the degree of division of labour and of mechanisation in the most advanced industries, from the point of view of mechanical or manual production, either in mass or in large groups, the human element remains the factor which determines industrial output. It would therefore be wrong to neglect this factor and to apply a materialistic reasoning in a domain where quality outweighs quantity.

As the presence of a man before a machine is a continual necessity, and as the lot of a person performing the work and his mind and body to a particular task cannot be neglected, it is of practical importance for the doctor to take into consideration the whole personality of the worker and to study the best means for ensuring healthy conditions of industrial employment. It must not be forgotten that the psychical reactions of the individual to his work are not the exclusive product of environment, and that no line can be drawn between occupational activity and the private life of the worker. The doctor has in consequence to exercise his influence under conditions which bring him into intimate contact with social service. As Myers remarks, it should always be borne in mind that industrial life occupies less than a third of the total number of hours in the worker's day, and that industrial strife is very often the result of the struggles arising from domestic life, or from inherited tendencies, or from experiences acquired, particularly in infancy or adolescence. On the other hand, as Tanzi affirms, it is not the mental effort required of the worker which exhausts him, but rather emotional disturbances and passionate manifestations. Efforts may therefore be directed towards alleviation of misery and suffering and avoidance of degrading work, rather than to the curtailment of mental activity.

PSYCHOLOGY OF THE WORKER

"For good mental health and the full development of the human personality, satisfaction in work and a good balance between the energy expended in wage-earning and the energy devoted to the wider issues of life are important." (Campbell.)

"Too often one thinks of the factory worker as a stolid automaton, unemotionally working out his hours, trudging home to an equally colourless wife to sup on a smelly stew, spending the evening in sleep, showing the face with occasional riotous celebration and with, never anything approaching thought or emotion." (Dershimer.)

Rather, as a matter of fact, is it exactly the contrary which occurs; and if, for want of education rather than of good intention, the psychic life of the worker does not manifest itself by refinement and intellectual development, it is none the less true that disregard of the rights of humanity injures the lowest grade of workers more than any other wrong. In the intellectual domain, the worker's reactions may be limited in consequence of his elementary instruction, but in his emotional and sentimental make-up there occur the variety and complexity which characterise the soul of a being whose organism is the heir of all humanity. In the case of the worker, his ideo-affective complexes often assume a far larger aspect, because in spite of inborn intelligence, which is often remarkable, his intellectual experience is not more extensive.

As regards the life led by workers there are obviously individual differences. If the degree of contentment, which depends on mental adjustment to the problems of life, is taken into consideration, there may then be distinguished, according to Dershimer, at least three types. He says:

"In industry, as in any other large group of people, it will be found that these degrees of adjustment and their results shade into each other somewhat as follows: at the top, perfect adjustment, contentment and efficiency; midway, restlessness and unhappiness; finally complete failure in adjustment leading to disease and outwardly to revolt."

Myers distinguishes the "surly" type of man who protests against a position, just because he happens to find himself in that position; the "resigned" type, whose personal hopes and aspirations have been destroyed; and the "practical" men who adapt themselves and know how to solve their difficulties.

The "surly" man is very difficult to deal with, and leaves work for motives which are apparently inadequate. The "resigned" man does not interest himself in his daily work; he works mechanically, but he is able to satisfy his aspirations by indulging his imagination in day dreaming; this worker does not feel the monotony of work. The third type is that of the man who satisfies his personal aspirations or his inclinations for leadership by a display of activity, or by filling an important post in social life.

It is essential to detect and evaluate the causes which may have an injurious influence on the psychic equilibrium of the worker.
According to Myers; there are three principal causes that make trouble between the worker and his industrial surroundings:

1. The management may be unsatisfactory;

2. The worker is not in sympathy with the work which is entrusted to him;

3. The worker suffers from a situation which hampers the development of his personal aspirations.

In this connection, Pratt notes that one of the most frequent causes of discontent is found among workers who have to support a family, but are employed on badly paid work, only calling for a small part of their abilities, and cannot find better employment. Their moral equilibrium is quickly destroyed, and their state of mind shows itself by exhaustion and signs of pathological fatigue, or by psychical reactions fostered by ill-feeling and resentment.

In a similar situation is the worker whose modest aptitudes do not come up to the requirements of the process at which he is employed. In this case the individual will react either by depression resulting in annihilation of the few aptitudes which he does possess, or by an increase of his ego which makes him disagreeable to his comrades and difficult for his chiefs to manage.

The duration, physical conditions and the rhythm of the work should also be taken into consideration.

Excessive hours of work may cause, under certain conditions, degrees of fatigue which react on the mental state of the worker, causing psychoses and neuroses; fatiguing work in a very hot atmosphere is an instance, as, for example, in the stoke-holes of large ships during voyages in the tropics (Durig). Excessive rhythm, as in chain work, may cause a state of nerve exhaustion accompanied by depression and uneasiness. The monotonous influences exerted by work should not be judged without taking into consideration the full personality and mental resources of the worker. Monotonous work is not necessarily displeasing to the worker, who may let his mind wander among memories and coming events of social life. In fact it is on the aspect and nature of these last that the healthy or unhealthy character of the interests of the worker and his mental attitude will depend. Indeed, monotonous work allows mental leisure which is unknown to the artisan who is entirely concentrated on his work. On the other hand, mechanical work contains the germ of a moral conscience for the worker which makes him happy or unhappy, according to the conditions of his existence, as to whether they are satisfactory or not. In the latter case, he will react by a mental attitude which, if not corrected by mental hygiene, will degenerate into a psychoneurosis and all kinds of psychic disorders, as trying to the worker himself as to those around him.

The causes mentioned may act in a collective manner, and lead to group manifestations which may disturb the moral equilibrium of the personnel and industrial peace. The presence of an element of discontent among workers is often sufficient to influence other workers by mental contagion. This danger is all the greater in the case of a psychopathic agitator, always a grumbler, who protests against everything and ceaselessly formulates his claims.

It is interesting to mention that strikes have been regarded as the result of such influences, for the conclusion has been drawn that, in these manifestations of collective life, the anti-social reactions of individuals, whose mental activity is often brilliant, although unbalanced, are found to be the start of the movement (Ball). Thus the strike has been regarded on the whole as a defensive reaction of those who cannot adapt themselves (Stewart-Paton), or of individuals whose resistance with regard to the demands of the work is found to be impaired (Pound). Anxieties in domestic life, irritation caused by those who supervise or the effect of an exaggerated responsibility arising out of work may, in a large number of workers, lead to the most varied forms of psychopathological reactions. There should be mentioned in the first place the syndrome known under the name of “neurasthenia”, which, according to Durig, may be almost considered as an occupational disease for some classes of workers: workers doing delicate work which requires an extremely rapid rate of rhythm, and also carries responsibility with it (Freund), as, for example, those employed on post office work, including telegraphists and telephone operators, chain assemblers and printers. According to an enquiry made by Leubuscher and Bibrowitz, which dealt with 150,400 workers affected with nervous conditions, this group contained 15.75 per cent. of printers (compositors), 9.43 of carpenters, and 3.9 of mechanics. Account must here
Mental Hygiene in Industry

also be taken, in the case of the printers, of the fact that their number represents only 1 per cent. of the insured workers examined; hence the conclusion may be drawn that in this occupation the number of neurasthenics is particularly high. The enquiry was also able to establish that the hereditary factor was only of secondary importance, for in three-fourths of the cases studied the diseased state was due exclusively to occupation.

The defects of mental adaptation, and the psychic disorders which follow, manifest themselves in a psycho-neurotic form. Contentions which have been nipped in the bud, complete repression of contrary instincts, and strangled emotion, such are the origins of manifestations called psychoasthenic, the most characteristic traits of which are the phobias and obsessions. They are the special idea-affective complexes corresponding to the conflicts, repressed instincts and sentiments, which tend to reappear in the conscience of the workers in the disguised form of fixed ideas, phobias, dreams, or of such symbolic actions as psychogenic tics.

The mind of the worker in some cases is haunted by a sense of defects in character or in psychic traits. In all these cases when no salutary influence is introduced by suppressing the causes, or setting the mind right by an adequate course of mental hygiene, psychic disorders may arise, repercussion from which may show itself in the occupational life of the worker; by a diminution in the capacity for work and a feeling of malaise which may be converted into a spirit of revolt.

A large number of psychic disorders become converted into bodily conditions, so originating such occupational nervous as telegraphists' and telephone operators' cramp, and miners' nystagmus, or certain respiratory disorders, or circulatory, digestive and somatic reactions associated with hysteria.

Very often the doctor who is not on his guard, and, still more often, the laity, are inclined to regard most of these affections as pretences, and to mistrust, as a disease-reality — taking refuge in sickness — a reaction which is only based on a failure in defence. The mental mechanism which psychological analysis has revealed should automatically enable an observer to find a solution for a given situation and not to seek an escape from it. The doctor should, by seeking the cause, help the patient to recover his psychic integrity.

Statistics

It has just been seen that the simplest signs of mental disturbance consist in a feeling of discontent caused by work. It is not the work in itself which plays a depressing part; it is the conditions under which the workers are called on to perform it.

According to statistics collected by Lewenstein in 1912, the majority of workers are not satisfied with the kind of work they do. The following are the results of his enquiry:

<table>
<thead>
<tr>
<th>Workers questioned</th>
<th>Mines</th>
<th>Textile Industry</th>
<th>Metal Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per cent.</td>
<td>Per cent.</td>
<td>Per cent.</td>
</tr>
<tr>
<td>'Satisfied'</td>
<td>15.2</td>
<td>7.1</td>
<td>17.0</td>
</tr>
<tr>
<td>'Discontented'</td>
<td>60.5</td>
<td>75.5</td>
<td>56.0</td>
</tr>
<tr>
<td>'Indifferent'</td>
<td>17.6</td>
<td>13.6</td>
<td>17.1</td>
</tr>
<tr>
<td>'No answer'</td>
<td>6.7</td>
<td>4.9</td>
<td>9.0</td>
</tr>
</tbody>
</table>

An investigation undertaken by Stevens, on the incidence during six months of functional nervous diseases among 4,000 workers of the Jordan Marsh Company has shown clearly that 405 (about 10 per cent.) suffered from an incapacity for work due to psychogenic nervous syndromes which had been the cause, as regards 123 individuals, of a loss of 1,546 working days which represented 3.2 per cent. of the total time lost on account of sickness by the whole of the workers of the firm. Further, among the diseases treated at the workers' dispensary, functional nervous affections occupied the fourth place.

Elkinds has made use of the medical reports on the personnel of an important public utility business, the reports being supplied by the Statistical Department of the Harvard School of Public Health. According to this work, which deals with a period of five years, functional nervous diseases appear with a percentage of 16 for the group of stenographers (chiefly women): 10 for the group of clerks; 10 for that of auditors of accounts; 7 for that of firemen; 4 for telephone operators (women). For the total of all occupations the percentage was 6.

The total number of lost working days was 6,882, giving an average of 9.4 per worker-year. The cost to the company for the treatment of sickness during five years reached $139,872.40, of which $19,383.50 was for functional nervous disorders, amounting for each of these patients to $27.20 dollars, an unprecedented figure when it is known that for other diseases the average cost was 92 cents.

Collis has made an interesting comparison between the prevalence of mortality among coal miners and the mental unrest which leads them to strike. Although his deductions were based on somewhat unrelated figures, yet the coincidence
cannot be denied (see article "Miners' Diseases").

**Prophylaxis**

Measures for preventing, as far as possible, influences which may prejudice the health of the worker's mind should be taken (a) before engagement and (b) after engagement.

(a) **Before engagement.** — Special attention should be given to the personality of a candidate at the time he is under consideration or selecting his occupation, by first and foremost ruthlessly eliminating the abnormal and weakly, for whom work should be found which is suited to their psychic conformation, or to their mental level. If left to their own devices, these persons are quite unable to enter into competition with normal beings, and would represent a wastage of 65 per cent. of cases; they ought to be aided by public assistance schemes.

This same attention should be given to the mental state at the time of the re-engagement of workers who have been victims of industrial accidents, or of nervous shocks, or have acquired mental defects at work. It is interesting to note that weak-minded workers do not find any difficulty in doing certain kinds of work. There are even some industries in which automatic machinery predominates, where only a minimum of mental effort is required; they are actually to be preferred for this type of work (Pratt).

The importance of selection must not be underestimated, from the point of view of the danger to which individuals whose mind shows defective reactions are exposed. For example, in an American factory which had at great cost put in a system of automatic protection against accidents, the frequency of accidents at the end of some months had only diminished by half of what had been hoped for. An enquiry showed that the cause was a small group of weak-minded workers and persons whose emotional instability and irresponsibility reached such a degree as to make them unemployable.

When examining such persons it is necessary to mistrust the value of so-called tests of intelligence. Very often disconcerting replies in this kind of examination do not exclude a satisfactory aptitude for a definite process (Elkind). In spite of lack of intelligence revealed by the tests, their value should only be considered as very relative. In other words, capacity for work does not depend only on intellectual functioning, but on the character and whole personality of the individual.

The doctor should be ever on the look-out to detect cases of insufficiency or mental defect, which may escape superficial observation and can only be discovered, and then with difficulty, at a moment when mental contagion clouds the mind.

(b) **After engagement.** — Periodical examination by the factory surgeon enables him to diagnose in good time psychic disturbances or cases of mental disease.

The importance of this medico-psychiatric care is shown by numerous practical experiments. Pactet found some general paralytics employed on a railway in important posts of considerable responsibility; Collin found an epileptic, a discharged soldier, who was only recognised as such owing to his violent behaviour towards a station master, following upon an epileptic seizure. Fortunately the number of workers suffering from mental diseases, properly so called, is low. On the contrary, workers showing psycho-neurotic disorders, either constitutional or accidental, are more numerous. The doctor should study the suitability of workers for their occupation and their environment, detect the causes of discontent, and advise measures suitable for creating conditions of general well-being. He should revive those that falter, clear up awkward situations, and intervene when reactions or feelings capable of causing collective nervous instability may appear to endanger industrial peace.

The doctor should also follow up the cases marked at the time of engagement as requiring medical attention. A workman diagnosed as mentally defective on engagement was employed as a labourer in a timber yard. As he was considered a good worker, a well-intentioned foreman thought well to promote him and make him chauffeur of a lorry. As long as the new chauffeur was only employed on transport work about the timber yard all went well; but one day he was sent outside and told to be quick. On the return journey he had to cross a level crossing and a fatal accident occurred. On account of his defective judgment, with an excessively slow reaction time, he was unable to avoid a collision with a train, which proved fatal for him (Pratt).

In the case of discontent showing itself by definite permanent psycho-neurotic symptoms, the doctor should find out all about the situation, and find a remedy either by helping the patient to struggle boldly against his
weakness or offering him a possibility of a compromise or compensation.

In the latter case, it is a question of providing an occupation which during the hours of leisure enable the worker to satisfy his repressed tendencies; it may be by reading, music, or gardening, according to the case, or by some more or less important social activity. In all these cases, the leisure hours of the worker should be fully occupied, while the view is not to be lost sight of that every factory pays two kinds of output: the manufactured article and the personality of the worker (Campbell).

The causes of bodily diseases and mental disorders are interwoven, especially at the factory, in an inextricable way; and it is difficult to separate mental health from physical health. Hence in order to know the mental condition of each worker there is need for a close contact between the doctor and the workers. But, for this observation, auxiliary methods can be made use of, e.g. reports from foremen, information furnished by the attendance registers, and the wage-sheets. Thus, a wage-sheets, which, by its variations, contrasts with the previous regular curve, may deter the doctor to arrange an interview with the worker; this may enlighten him as to the cause, showing whether a physical disease is present, a latent state is present, or an emotional factor brought on by the conditions of work in the workshop or even by trouble at home, the repercussion of which is felt at the works. Campbell mentions the case of a working woman with an erratic wage-curve, whose bad output was due to pre-occupation quite unconnected with the work; she had left her two children in charge of a sister who had a perverted character, and she was uneasy about the moral state of her children, and was always thinking about it.

Resentment, anxiety, a feeling of injustice or of inferiority, of timidity or disappointment, discontent caused either by work or by the conditions of private life, may disturb the mental equilibrium of a worker. These troubles are generally indicated by irregular attendance at the works, waste of time, and fluctuations in the wage-curve. It is the duty of the doctor to recognise the cause of these symptoms and not to consider them as manifestations to be dealt with by disciplinary measures, reduction of wages or reprimand.

Clearly the practice of mental hygiene at a factory requires that the doctor should have, in addition to his general training, special psychological and psychiatric knowledge, which is indispensable for ensuring useful intervention at an early stage when a worker comes for consultation without showing symptoms distinctive of a definite stage. Only a skilled doctor will be able to detect the disturbance which has occurred in the mental stability of the person from symptoms of no apparent importance, and to recognise that every assistance should be given to help him to fight against the threatened condition.

As a matter of fact, the number of factory surgeons who have to the present time had psychiatric training is not large. Read states that modern schools of medicine train doctors who have had no psychological training and have never hitherto considered this disciplinary training. The factory surgeon who finds himself concerned with mental hygiene should not forget that this aspect is different from the older point of view of medicine, which was only concerned with definite clinical pictures. It is a question of a new mentality, the object of which is to prevent mental disorders by tracing their sources of origin and by using the means which psychological and psychopathological science have placed at the disposal of practitioners.

Mental hygiene does not encounter in industry simple problems which can be referred to one specific injurious agent. In order to practise mental hygiene in an efficient manner it is necessary to know how to sympathise with the worker, to study carefully his surroundings, his chances of recreation, his aspirations and disappointments. In a word the doctor who is to be successful in this work must be familiar with the organisation of social service. However perfect the condition of the factory may be, the health of the mind of the worker cannot be maintained if he goes back to a wretched and unhealthy home. With a view to encouraging the development of the practice of mental hygiene in the workshop, Genil-Perrin insists on the necessity for organising "psychiatric dispensaries", which have shown their value in America and have achieved a clearly defined place among the working classes and in manufacturing centres. Hence for this reason nurses attached to a factory should have some psychiatric training. Genil-Perrin sums up the principles of hygiene and mental prophylaxis in industrial areas in the following desiderata:
(1) The establishment of the best psychological conditions of industrial work with a view to making the best use of the mental effort of the worker, which increases in importance in proportion to his physical exertion.

(2) Psychophysiological selection of workers with a view to systematic direction of the worker's choice of work according to the special bodily and mental fitness of each individual.

(3) Systematic examinations of working communities, with the elimination of subjects predisposed to psychic disorders in order to withdraw them from tasks which are dangerous and full of difficulties and to submit them to special mental hygiene, each case receiving individual attention.

(4) A service of psychiatric registration organised by private initiative and public administrative bodies.

(5) Co-operation between the factory medical service with psychiatric dispensaries and laboratories of experimental psychology.

Mental hygiene at the factory clearly encounters great obstacles. The intervention of the doctor itself too often causes a feeling of distrust on the part of the worker, and whenever it is a case of examining or protecting his mental state, he is apt to feel placed in a state of inferiority. But, wherever mental hygiene has been practised, satisfactory results seem to show that it is worth while to deal with the moral and intellectual health of the workers. Dershimer has observed that the works doctor is now called on to replace the family doctor of former times. The latter used to know all the joys and anxieties of his patients, to whom he was the counselor and friend as much as doctor; he knew all the joys and anxieties of his mental state, is part of the worker, and whenever it

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Mercury (Quicksilver)

French: Mercure. — German: Quecksilber. — Italian and Spanish: Mercurio.

CHEMISTRY

The only liquid metal. Symbol: Hg. Specific weight: 13.595 at 0° C. Boiling point: 357.3° C. Solidifies at approximately 92.4°. Heated in the air mercury oxidises, and this oxide, carried to incandescence, yields mercury and oxygen again.

Mercury undergoes fairly rapid change at ordinary temperatures and becomes coated with a fine layer of mercurous oxide (Hg,O). Treated with cold nitric acid, mercury becomes converted into mercurous nitrate (HgNO₃), which dissolves in excess of the acid. Mercury has no action in a cold state on sulphuric acid; on heating, it yields sulphurous anhydride and mercurous sulphate according to the temperature. It is not attacked by cold hydrochloric acid.

For the principal compounds of mercury see article "Mercury (Compounds of)".

With most metals it forms "amalgams" readily—not so easily with copper. It forms no amalgam with iron, nickel, aluminium, cobalt, and platinum.

Vapours. — Mercury gives off vapour at ordinary temperatures and even at the temperature of solidification; these vapours are very abundant at high temperatures.

21.1 —
Hertz has calculated the volatilisation of mercury per cubic metre of air as follows:

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>0°</th>
<th>10°</th>
<th>20°</th>
<th>30°</th>
<th>40°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg. of mercury</td>
<td>2.2</td>
<td>5.7</td>
<td>14.3</td>
<td>31</td>
<td>78</td>
</tr>
</tbody>
</table>

Kunkel found, on the contrary, at the same temperatures:

| Mg. of mercury | 4.2| 6.8| 10.4 |

According to the experiments of Renk, the quantity of mercury in the air at a temperature of 10° C. over a surface of 0.5 sq. metre of mercury was per cubic metre of air:

- 1.86 mg. at 5 cm. above the surface.
- 1.29 .. at 50 cm. .. .. ..
- 0.85 .. at 1 cm.  .. .. ..

Mercury vapour is heavier than air, but it does not localise itself in the lower part of a closed space (the laws of gaseous mixtures differ from the laws of liquid mixtures). Vapour produced at a high temperature has a tendency to rise.

**Sources of Intoxication**

*In its preparation:* see article "Mercury (Mines of)".

*In its use:* mercury is employed in the metallic state (cold, or in the form of vapour disengaged by heat) or in the form of compounds. The processes which expose to intoxication, either by contact with the metal or by inhalation of vapour, are very numerous, and opportunities of intoxication in the industrial field are increasing. The principal processes are as follows:

- Filtering of mercury. Treatment of argentiferous or auriferous metals. Treatment by heating of amalgams of silver or gold for the recovery of precious metals. Treatment by heat of amalgams by dental mechanics and dentists. Alloys with tin and copper containing about 5 per cent. of mercury. Amalgamation of zinc in factories making accumulators and electrodes amalgamated with zinc. Preparation and use of lead mercury solder (much employed during the war). Manufacture of scientific instruments, such as barometers, manometers, thermometers, mercury switches, mercury vapour lamps, and freezing machines. Manufacture and use (becoming less common) of mercury pumps.1

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1 At the South Meadow boiler works (United States) cases of mercury poisoning occurred, but it was possible to prevent entirely the occurrence of further cases.

In another boiler works at Dutch Point an experimental boiler became cracked, with consequent loss of 2 tons of the 20 tons of mercury constituting the initial charge. The 2 tons became vapourised and were withdrawn partly by way of the chimney without affecting the workers. On another occasion an accident occurred as the result of the rupture of a defective pipe, but since the temperature of the fumes in the chimney did not exceed 150° C. the mercury became condensed.

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**Toxicity**

Ingested in the metallic form in large quantities mercury does not appear to have great toxicity, but if finely divided or remaining for a long time in the digestive tract it can have very serious effects. The toxicity of the compounds of mercury (see that article) is also notorious.

The toxic dose of the vapour of mercury cannot be stated. According to Göthlin, for example, 0.4 to 1 mg. of mercury inhaled daily in the form of vapour (0.02 mg. per 28 cub. cm. of air, according to J. A. Turner, U.S.A., 1924) would set up gradually chronic poisoning. Workers employed 8 hours in a room containing 0.1 to 1 mg. of mercury per 4,000 litres of air showed 0.4 to 1 mg. of mercury in the urine.

Absorption of the metal by the skin is possible, especially if this is cracked; it occurs with the skin intact if mercury is vigorously rubbed in with fatty substances (for example during cleaning operations which facilitate absorption by the skin). The real danger, however, is inhalation of the vapour, for the droplets suspended in the air when they enter the mouth or the nose volatilise as a result of the rupture of a defective pipe, but since the temperature of the fumes in the chimney did not exceed 150° C. the mercury became condensed.
data exist regarding the resistance of the race, individual, or hereditary resistance to mercury and its compounds, but women are, however, said to be particularly sensitive to these poisons. (See "Mercury (Mines of").

Elimination.—Takes place chiefly through the salivary glands, the mucosa of the great intestine and the kidneys (markedly hit in the course of the intoxication because of the direct irritation by the mercury eliminated), by the skin, the bile, the milk, and the sweat. Elimination by the saliva and urine is not constant and uniform, because it is possible to detect mercury in the faces and urine even several months (six to nine and more) after the cessation of contact with the poison.

Statistics

The first case of occupational poisoning was reported about 1557 by Fermel, who instances the case of a worker, a gilder, who became deaf and dumb after mercury poisoning. Forestius, in 1600, while investigating occupational mercurialism, tells of a gilder who became paralytic as a result of exposure to the fumes of the metal. Walter Pope, towards 1655, relates that on visiting the mines of Friuli he noted, amongst the workers engaged on extracting the metal, certain symptoms of poisoning, such as trembling, paralysis, and mercurial cachexia.

Austria.—Six cases of mercury poisoning were reported in 1913 among 30 workmen in a workroom using cyanide of mercury, and 2 severe cases were caused by sublimates among masons who had to work in a vat which contained a solution of sublimates.

France.—Cases of mercurial poisoning notified in accordance with the Act of 1919 numbered 6 in 1922, of which 7 occurred among hatters' furriers, and 1 was that of a worker engaged in handling mercury ointment (druggist). From 1923 to 1927, 29 cases of mercury poisoning were reported as having occurred in hatcutting and caroting departments (21 cases); in the manufacture of mercury thermometers (4); in the hat industry (1); in the making of electric batteries (zinc amalgam) (1); in making special iron-nickel batteries (1); in an industrial photographic studio.

Great Britain.—From 1899 up to December 1923 the Medical Inspectors' reports showed 229 reported cases of mercury poisoning, distributed as follows: 1899-1912, 133; 1913, 14; 1914, 10; 1915, 6; 1916, 18; 1917, 17; 1918, 9; 1919, 7; 1920, 5; 1921, —; 1922, 6 (with 1 death); 1923, 4.

In the 229 cases the industries were:

52: Manufacture of explosives with use of fulminate of mercury;
47: Manufacture of thermometers;
25: Hatters' and furriers' processes;
25: Manufacture of electrical meters;
23: " felt hats;
21: " chemicals;
19: Various;
8: Watergilding;
4: Manufacture of mercury lamps;
3: Bronzing;
2: Photogravures.

For the period 1924 to 1930 the total number of cases of poisoning was 64: 1918, 8; 1919, 10; 1920, 8; 1921, 7; 1922, 8; 1923, 11; 1924, 4 (1 fatal); 1927, 3 (2 fatal); 1928, 4; 1929, 0; 1930, 3.

Germany. — Several cases have been reported in the industry (see article "Pulminiae of Mercury"), and some also among women working in a foundry making a mercury alloy (1914-1918). Mercury poisoning has been noticed amongst workers in institutes of technological chemistry (professors and assistants), and Holtzmann has estimated at 80 per cent the incidence of positive symptoms in cases brought to his notice (1929). Four cases of acute mercury poisoning affected locksmiths engaged in repairing boilers used in factories in which mercury was utilised (Hopmann). In Bavaria, in 1913, of 13 workmen examined about one-half showed signs of chronic poisoning in a factory for the making of sublimate pastilles (psychical disturbance, changes in the teeth); 3 cases occurred amongst apprentices in a thermometer factory, and 3 were the children of a thermometer worker carrying on his business as a home industry, with 3 other cases among glass blowers who poured mercury into glass tubes. Between 1914 and 1918 several cases were reported among solderers using an alloy of lead and mercury, among workmen employed in the manufacture of acetone (using acetylene as the starting point), and a photographer's apprentice was also affected.

Netherlands. — Cases are reported among persons using sublimate in making the elements for the accumulators of pocket electric torches.

Switzerland. — The National Accident Insurance Fund received notice of 8 cases of poisoning in 1918, 10 in 1919, 10 in 1920, and 12 in 1921, distributed as follows: 1 among gunsmiths, 2 among laboratory assistants, 2 among fitters and various workmen, 3 among foremen, 4 among locksmiths, and 28 among other workers. In 1922 cases of poisoning amounted to 11; in 1923 to 4; in 1924 to 14; and in 1925 to 70.

For details see the articles "Mercury (Mines of)", "Mercury (Compounds of)", "Pulminiae of Mercury", "Hatters' Processes", etc.

United States. — Four cases of sub-acute or chronic poisoning were reported amongst workers occupied at electric furnaces (high frequency induction), in the neighbourhood of which analysis of the atmosphere showed the presence of 7 mg. of mercury vapour per cub. metre of air (Jordan and Barrows).

Symptoms

The industrial poisoning is generally markedly chronic from the first; but acute exacerbations in the advancing chronic cases also occur, characterised by attacks always more frequent with increase of the motor signs. Nowadays, however, slight cases predominate as compared with the severe type so frequent formerly.

The clinical picture under these conditions shows little that is characteristic, and in consequence calls for very close attention on the part of the medical man.

The earliest symptoms, little characteristic, affect primarily the digestive tract and nervous system; but in time the poison brings about other very serious changes in the body (chronic nephritis, cachexia, etc.).

Digestive system. — The first symptoms, although little characteristic, are a metallic taste, anorexia, vomiting, gastric catarrh, chronic diarrhoea from the first or in crises, but above all stomatitis, which is the thermometer of mercurialism. It is very often chronic from the start and it generally follows acute and successive functional troubles. Moreover, predisposition is caused by inflammation or dental or oral lesions (dental caries, gingivitis). There is foetid breath, spongy or ulcerated gums, salivation attended with some foetor of the breath) amounting to several litres daily. The teeth undergo changes, becoming blackened, fragile, blunt, and eroded. At a later stage they fall out — especially the lower teeth — a consequence of a process of expansive gingivitis, often accompanied by abscesses. The healing of the buccal lesions as soon as no more teeth remain, or at least around teeth that have fallen out, should be noted. The tongue has been found to have a silvery aspect with indented edges (Legge). There is rarely dental nervergia. Some authors have given prominence to the presence of an inflammatory line on the gums round the upper teeth (see article "Hatters' Processes"), accompanied frequently by tattoo plaques on the mucous membrane of the lips and cheeks; this line may, however, be absent.

Sometimes the stomatitis takes the form of a purulent gingivitis with foetid discharge (alveolar dental pyorrhoea). The tonsils and pharynx also are sometimes inflamed (mercurial pharyngitis of Kussmaul). As an ultimate, though rare, effect of the stomatitis, necrosis of the maxillary bones is said to occur. The stomatitis is accompanied by
objective (pains, headache) or functional symptoms (anorexia, fatigue, etc.).

**Blood.** — At the same time the affected person becomes emaciated with more or less anemia, generally moderate. Effect on the blood is not characteristic and on the whole not comparable with that observed in other industrial intoxications, notably lead poisoning. The colour index and hemoglobin are very little lowered; the resistance, shape, size, and chromatic characters of the red cells are normal. Any diminution is at any rate late; punctate basophilia is very rare even in severe cases. Similarly, white blood cells are quantitatively normal, and their diminution or increase exceptional. A mononucleosis (lymphocytosis), however, and even complete inversion of the leucocytic count has been described; also a slight degree of chronic intoxication, and in withdrawing the person from the action of mercury a rapid improvement takes place corresponding with the renal excretion of the poison.

**Neuro-muscular system.** — Later, or even at a fairly early stage — especially in the predisposed — the neuromuscular system becomes involved, a real condition of "petit mal" showing itself in pronounced mental hyperactivity (mercurial erethism), morbid nervousness from which few affected persons escape, sensibility almost amounting to a neurosis, sensation of anxiety, painful embarrassment; then torpor, somnolence, marked mental hebetude with (rarely) attacks of acute mania, profound mental failure, paralytic dementia, loss of memory, etc. Most notable of all — especially in men employed in

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**Fig. 20.** — Mercurial Tremor. *The attempt of an illiterate patient to reproduce the arms on the right of the diagram.*

increase in the eosinophilic leucocytes. Donajewsky and Peissachowitsch (1930) found chiefly lymphocytosis and a mylogenous reaction manifested by eosinophilia and monocytosis. These authors, not having succeeded in establishing any connection between the occupation and the changes observed, considered that such alterations of the blood may not be regarded as specific. Workers recently engaged in handling mercury showed the most marked blood changes.

According to some writers, these symptoms show profound mercurial impregnation (rather than a latent intoxication) and indicate imminent severe nervous manifestations. They are said to be even proportional to the mercury mines — tremors, and tonic and clonic spasms are characteristic (the "calambras" of Spanish miners, the "stolzi" of Italian miners). Muscular strength is diminished, troubles of nutrition, usually mild, are not uncommon, as well as partial paralyses localised specially in the extensors (actual paralyses are rather rare), sensory effects (anaesthesia, arthralgia, hyposthenia), neuritis (rare), difficulty in walking, hysterical symptoms as an indirect consequence of the intoxication and related notably to individual predisposition.

Apart from the psychical manifestations described, all persons affected suffer from tremor and muscular incoordination, which is an early sign and
often the only one (especially after inhalation of vapour). Trembling was first described as a very special symptom of mercurial poisoning among metal gilders by Ramazzini, and later on by Martin de Guinard and Merat in 1818. In 1848 Th. Roussel expounded a very clear theory of this motor derangement and painful convulsive crises found among miners at Almaden. In 1861 Kussmaul published his classic work on mercurial poisoning. Mercurial tremor shows itself in slow and progressive manner, but occasionally appears suddenly with great intensity. It varies from the slightest tic to chronic incoordination of the intensest kind, and can hinder the upright position. Generally tremor takes the form of slight oscillations, slow ("vibratory tremor" of Charcot), more or less rapid or rhythmical and localised in the face (lips, tongue)—to the left in left-handed persons—and extending then to the head, trunk, and to all the limbs with attacks of clonic shaking. It has the appearance essentially of being intentional, the effect of emotion becomes increased if the sufferer is watched. Its nature is still much discussed, whether toxic or organic or even hysterical. The toxic cause of the tremor seems to be quite definite, particularly on account of the infrequent but definite trace of mercury in the cerebro-spinal fluid. The extension of the phenomena, their aggravation due to multiple external influences and their evolution, etc., are the outcome of the very conditions under which tremor appears and develops. When the tremor is in the tongue, the affected person has naturally difficulty in pronunciation and especially at the commencement speech is hesitating and uncertain.

Cardio Vascular system. — Reisel- man (1930) has reported cardio vascular symptoms in workers suffering from mercury poisoning. These consisted of lesions of the myocardium or of cardio neuropathy and the symptoms noted were cyanosis of the extremities brachymercury poisoning. These consisted of loss of vision due to multiple external influences and their aggravation due particularly on account of the infrequent tremor. It has the appearance essentially of being intentional, the effect of emotion becomes increased if the sufferer is watched. Its nature is still much discussed, whether toxic or organic or even hysterical. The toxic cause of the tremor seems to be quite definite, particularly on account of the infrequent but definite trace of mercury in the cerebro-spinal fluid. The extension of the phenomena, their aggravation due to multiple external influences and their evolution, etc., are the outcome of the very conditions under which tremor appears and develops. When the tremor is in the tongue, the affected person has naturally difficulty in pronunciation and especially at the commencement speech is hesitating and uncertain.

Kidneys. — Rarely has chronic mercurial nephritis any special features. The urine presents no chemical change which would differentiate it from that of an ordinary chronic nephritis. At the same time the well-known condition may occur.

Ocular lesions. — Ocular lesions are represented by an amblyopia due to a retrobulbar neuritis. This lesion, often unilateral, will extend to the other eye unless of course it is immediately withdrawn from the action of the poison. At first diminution of vision is observed with small paracentral colour scotomas; later visual interference rapidly increases.

Sexual functions. — Frequent cases of miscarriage among women workers engaged on work which exposes them to mercury poisoning are said to occur, and even among wives of poisoned workmen. (See article "Mercury (Mines of ").)

Skin. — The local action of mercury sets up frequently in the newly employed dermatitis, eczema, cracked skin, lesions of the fingers sometimes severe in work of the most varied kind (solderers, founders, chemists, accumulator workers, etc.). See articles "Mercury (Compounds of)", "Hatters Furriers' Processes", "Fulminate of Mercury", etc.

In addition to the usual factors which predispose to poisoning, the social condition of certain groups of workers (see article "Mercury (Mines of ") should be borne in mind, especially the influence of alcohol. Those who are affected by mercury are very susceptible to the action of alcohol, which not only makes the symptoms worse, but acts as a valuable stimulus in bringing out latent mercurial tremor.

DIAGNOSIS

Stomatitis, loss of teeth, anaemia, and especially tremor, brought out or increased by alcohol, are sufficiently characteristic of chronic cases. Examination of the blood does not help. Search should always be made for mercury in the urine, in the substances which may be suspected to contain mercury as, for instance, the air of the workroom (fumes, dust), and on the work-clothes. But it should be borne in mind that elimination of mercury by the urine is neither constant nor regular, and that mercury is often absent even in the most typical case of poisoning. The industrial causes are sometimes difficult to discover, especially when the compounds of mercury or of the metal itself are employed under another name or mixed with other toxic materials (as, for example, lead, etc.).

SEARCH FOR, AND DOSAGE OF, MERCURY

(a) In the urine it is not necessary to destroy beforehand the organic matter. With a strip of copper cause the deposition of mercury on a strip of platinum (Mer- get's method); determine the quantity of mercury deposited, by colorimetric comparison of the stains produced by compres-
sion of the platinum strip dried between filter paper sensitised by ammoniacal nitrate of silver. The reaction is sensitive to 0.25 mg. of mercury in 500 grm. of urine. There has also been proposed spectroscopic examination of the radiation emitted by a modified Geissler-Plucker tube in which has been inserted a copper wire previously dipped in a liquid to be analysed. This method is said to have a sensitivity of 1: 500,000,000 (Le Faso). The reaction with ammoniacal nitrate of mercury is applicable to all the compounds of mercury, but it is necessary to heat the compound with dry soda to liberate the vapour of mercury.

by means of chloride of lime through a glass tube 2.3 mm. diameter and 24 cm. long, into which some crystals of iodine are introduced. On heating, a reddish yellow deposit of mercuric iodide forms above the spot where the iodine lies and this is dissolved in potassium iodide. Filter rapidly to separate the iodide crystals which remain; absorb the excess of iodine by the addition of sodium hydrate until the colour disappears. Determine the mercury by electrolysis or colorimetry. In the latter case convert the iodide of mercury into the black sulphide by treatment with hydrogen sulphide and by comparing with alkaline solutions of mercuric chloride of known titration treated similarly with hydrogen sulphide.

(b) Blood. It is impossible to show the presence of mercury because the metal is present in infinitesimal quantity in the small quantity of blood which can be dealt with in practice.

(c) Feces. In analyses that have been made mercury was present in minimal amount.

(d) In the air of workrooms. (1) Kunkel's method: Pass the air slowly (1 litre at most in 8-10 minutes) filtered and dried by means of chloride of lime through a glass tube 2.3 mm. diameter and 24 cm. long, into which some crystals of iodine are introduced. On heating, a reddish yellow deposit of mercuric iodide forms above the spot where the iodine lies and this is dissolved in potassium iodide. Filter rapidly to separate the iodide crystals which remain; absorb the excess of iodine by the addition of sodium hydrate until the colour disappears. Determine the mercury by electrolysis or colorimetry. In the latter case convert the iodide of mercury into the black sulphide by treatment with hydrogen sulphide and by comparing with alkaline solutions of mercuric chloride of known titration treated similarly with hydrogen sulphide.

(2) Method of Heim and Herbert: Aspirate a known volume of air as in the preceding method over a certain quantity (10 cub. cm. for example) of a decinormal solution of iodine; destroy the excess of iodine which colours the solution strongly by the addition, drop by drop, of the quantity just necessary to do this, of a solution of hyposulphite of soda 25 per 1,000; bring the discoloured liquid up to

Fig. 30. — Mercurial Tremor. The patient's attempt to sign his name.
a total volume of 30 cub. cm. by adding distilled water, and add to it 2 cub. cm. of an aqueous saturated solution of hydrogen sulphide, freshly prepared, which causes the formation of a blackish reaction of colloidal sulphide of mercury. Compare the tint of the liquid with that of mercurial solutions treated in exactly the same way and of known content of mercury. The reaction shows 5 hundredths of a mg. of mercury.

A third method is based on the reaction between mercury vapour and selenium sulphide easily perceptible to the eye by change of colour. The reagent consists of a tissue paper covered with a light coating of yellow selenium sulphide which, on exposure to air containing mercury fumes, becomes blackened by the formation of mercury sulphide. The degree of blackening varies with the quantity of these fumes and with the length of exposure. The reaction permits of detection of mercury in the proportion of mercury of 1: 20,000,000 (General Electric Company, United States).

Many processes for determining mercury in the air and in organic liquids demand conditions which are rarely possible for medical men and properly belong to toxicologists.

**HYGIENE**

In industries and processes making use of mercury in the metallic state, the preventive measures prescribed for the metallurgy of mercury are required. (See article "Mercury (Mines of ").) Further, provision of the general regulations laid down for unhealthy industries is called for (see article "Industrial Hygiene (Workshops "): the metal should be kept in a place efficiently ventilated. It must be admitted that in certain processes when mercury is dealt with in small quantities (manufacture of scientific instruments, of thermometers, etc.), application of the measures outlined is attended with some difficulty. At the same time neutralisation of the effects of mercury vapour should be recommended by sprinkling on the floor every evening ammonia, or sulphate of ammonia, or very small quantities of hypochlorite of lime, or by hanging up sponges soaked with one or the other. Nitric acid fumes, produced by means of a special apparatus, are said by some authorities to give good results. Similarly, cleaning of the floor by means of special compositions of sulphur or tin which form amalgams readily with mercury has been suggested. All home work which involves contact with mercury or its compounds should be prohibited.

The cautionary notice which should be affixed in workrooms, e.g. in France (Order of 9 October 1913), is thus worded:

Mercury and its compounds are poisonous. They can enter the body with the air breathed, as dust and vapour; with food; through dirty hands, dirty benches; through the skin; through cracks, scratches and cuts.

If you have cracks, scratches or cuts, inform the foreman immediately.

Before partaking of food or drink carefully wash the hands with soap and the mouth with good drinking water.

Consult a doctor immediately if you notice excessive salivation, tremor, swelling of the legs, the hands, or under the eyes.

For personal hygiene see article "Mercury (Mines of ") and the following: "Mercury (Compounds of ")", "Fulminate of Mercury ", "Hatters Furriers' Process ", "Gold ", etc.

**LEGISLATION**

For the production of mercury, see article *Mercury (Mines of ")*.

Adult women, as well as young persons less than eighteen years of age, are excluded from all employment involving handling of mercury and its compounds in the Netherlands. Women and young persons below fifteen years of age are excluded from all work exposing them to dust and fumes of mercury and its compounds in Japan. Women and young persons under eighteen years of age are excluded from all work exposing them to mercury fumes in France and Switzerland. The handling of mercury and its compounds by young persons under sixteen years of age and women under eighteen is prohibited in Greece.

Exhaust ventilation locally applied for the removal of vapour and dust, washing accommodation, douche baths, dressing room, overalls or special clothing are provided for in the Netherlands.

**Medical examination on engagement:** expedient (see article "Mercury (Mines of ").) *Periodic examination:* also expedient. In Austria it is made obligatory once a year for all persons employed in industries using mercury. The intervals of examinations can be varied according to the danger.

**Notification of mercurial poisoning** (sometimes required for particular symptoms only). Obligatory in the following countries: Austria, Bavaria, United States (Connecticut, California, Maine, Maryland, Michigan, Missouri, New Jersey, New Hampshire, Wisconsin), France, Great Britain and the Dominions, Netherlands, Poland, Prussia, Saxony, Switzerland, Jugoslavia. Section 21 of the 1911 Act in the Netherlands requires notification of mercurial poisoning among workmen in the following industries: chemical factories and laboratories; explosives works; manufacture of pharmaceutical products and dressings; textile printing works; laboratories for mounting and repairing instruments; incandescent lamp factories; processes in
Mercurial poisoning is assimilated to accidents for purposes of compensation in those countries which have ratified the 1925 International Labour Convention concerning workers' compensation for occupational disease, and likewise in those possessing a Compensation Act: Alberta (Canada), Argentina, Austria, Belgium, Bolivia, Brazil, British Columbia, Bulgaria, Canada, Chile, Cuba, Finland, France, Germany, Great Britain, Hungary, India, Italy, Japan, Latvia, Luxembourg, Minnesota (Canada), Missouri, Netherlands, New York, New Brunswick, New Jersey, New Zealand, Norway, Nova Scotia, Ohio (U.S.A.), Ontario (Canada), Porto Rico, Portugal, Queensland (Australia), South Africa, South Australia, Sweden, Switzerland, Tasmania, U.S.S.R., Venezuela, Victoria, Western Australia and Yugoslavia. See also the articles cited above.

**BIBLIOGRAPHY**

See "Mercury (Mines of)".

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**Mercury (Compounds of)**


Mercury gives rise to two series of compounds: mercurous compounds (derivatives of mercurous oxide) and mercuric compounds (derivatives of mercuric oxide). The first group comprises mercurous oxide (Hg₂O), the chloride or calomel (Hg₂Cl₂), the bromide and mercurious iodide, the nitrate (HgNO₃); the second group comprises mercuric oxide (HgO), mercuric chloride or sublimate (HgCl₂) mercuric iodide, the cyanide, mercuric nitrate (Hg(NO₃)₂), the sulphate, the sulphide or cinnabar, etc.

Certain compounds are dealt with in special articles; thus, for example, the cyanide, the nitrate (see "Hatters Furriers' Processes", and "Fulminate of Mercury"; see also the other articles on "Mercury").

These compounds are generally prepared either by a dry or wet method. One of the solutions of mercury in acid is mixed with other substances which, under the action of heat or of the reagent, precipitate from the solution the product in an insoluble form. The product obtained is washed, filtered, dried, ground, and after being mixed with the necessary ingredients, packed. In the dry method the compound is obtained by sublimation in an enclosed apparatus.

Mercurous chloride or calomel is found, in very small quantities, in nature; artificially it is obtained by the wet method by precipitating a mercurous salt by a chloroide, or by the dry method by subliming a mixture of mercurous chloride and mercury, or of the sulphate of mercury and common salt (Japan). It is used sometimes in the decoration of porcelain and the making of fireworks.

The cyanide and perchloride are used in making dressings, and the former also in gilding (see that article) or in the preparation of cyanogen. In sublimate is used as a disinfectant, for making the pocket dry cell — a primary battery, for stuffing animals, etc. It easily destroys the stratum lucidum of the skin, giving rise to lesions, sometimes deep and painful, of the hands (fingers), especially among apprentices.

Nitrate of mercury is used not only in the curating of rabbit fur (see "Hatters Furriers' Processes"); but also in gilding, work, decoration of porcelain, bronzing of steel, and embossing, etc. It gives rise to skin lesions analogous to those set up by sublimate.

The sulphide or cinnabar is found in nature (see "Mercury (Mines of)"); is produced artificially by a dry method (sublimation of a mixture of sulphur and mercury, grinding under water, washing with hot and cold water, and with potash, drying), or by a wet method (vermilion: digestion of the white precipitate by the yellow ammonium sulphide, or by heating a mixture of mercury and sulphur with a solution of sodium hydrate). It is well here to call attention to the fact that, commercially, a pseudo-cinnabar is recognised which consists of minium (see that article) mixed with artificial red organic colours, and even a kind of lake which consists of barium sulphate and eosin, and afterwards treated by acetate of lead or alum (see also article "Antimony"). Cinnabar red is a colour much in demand. Although only slightly soluble it can set up mercurial poisoning.

Among the other compounds of mercury which deserve to be cited are: the mercuric iodide (which sets up general poisoning and a very marked cutaneous eruption), the bichromate (very irritating), the mercury-phenyl acetate (which is made by heating a mixture of mercury acetate and benzene at a temp. of 110° C., that is to say, acetate with a base C₂H₅HO, hydroxide of Hg-phenyl), the mercury-phenyl (Hg₂C₂H₅), (which is a metallic aromatic compound arising from the reaction of sodium amalgam on bromo benzene; in distillation it decomposes partly into mercury and partly into diphenyl), the mercury-methyl and mercury-ethyly (which have at times set up sub-acute and chronic poisoning), etc.

Salts of mercury are employed as catalysers in making certain substances (acetic aldehyde, synthetic alcohol, etc.), in which case they decompose more rapidly and the mercury is precipitated in metallic form at the bottom of the reaction vessel. In certain patent processes the mercuric salt...
is regenerated at the same rate as it is decomposed.

Among the statistical data it will suffice to recall those as to poisoning by sublimate reported from Bavaria, for instance (1913), among persons employed in two pastille factories, when one-half of those examined (13) showed symptoms of erethism, blackened teeth, stomatitis, and lesions on the fingers; in Austria (1913) among men employed in the manufacture of salts of mercury by the dry method; in the Netherlands (1915) among workers employed in the manufacture of sublimate pastilles and in preparing the elements of batteries for electric pocket lamps (the air of the workroom for assembling the elements contained 2.9 per cent. of sublimate).

**HYGIENE**

Work should be carried on in an enclosed apparatus with exhaust ventilation applied to the vapour and poisonous dust: in addition all the usual measures required in the manufacture and handling of poisonous substances should be adopted. (See articles "Mercury (Mines of)", etc.

**LEGISLATION**

In France exclusion of women from the manufacture of sulphate of mercury, of chloride, and of colours containing mercury (the Netherlands exclude them also from handling it when preparing it for delivery and use); in Italy, exclusion of female young persons under the age of sixteen years and boys under fifteen from the manufacture of alloys containing mercury; in Spain, exclusion of male young persons under the age of sixteen and female young persons under twenty-one years from the manufacture of sulphate of mercury; in Spain, exclusion of female young persons under the age of sixteen from the manufacture of sulphate of mercury, as well as from the manufacture of colours containing mercury. (See also article "Mercury".)

Compulsory notification of cases of cancer of the skin and of cancerous tumours affecting workers in workshops in which impregnation of wood by means of a sublimate solution is effected (Netherlands).

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**Mercury (Mines of)**


The only ore of importance containing mercury is cinnabar or sulphide of mercury (HgS), of which the beds consist generally of clay, siliceous rocks or calcareous rocks bearing cinnabar, rarely pure cinnabar. Native mercury is rarer still; zones of schist are met with at Idria (Italy), impregnated with minute droplets of mercury or of small real layers of metallic mercury at Almaden (Spain) and at New Almaden (U.S.A.).

The richness of the minerals in mercury is very variable; from 0.5 per cent. on the average (Monte Amiata, Istria, Italy), to 1.0 per cent. (Nikitomba, Russia), 2.5 (Brewster, Texas, U.S.A.) and even more (Almaden, Spain). In the case of certain cinnabar-bearing minerals in Hungary which contain at the same time much copper (40 per cent.) and antimony (30 per cent.). The mineral can also contain lead and arsenic (Almaden); similarly, mercury can be found in other minerals (e.g. spelter ores — see article "Zinc").

**PRODUCTION**

Deposits.— Of the beds still being worked to-day, those of Kwei-Chan (China) have been known from time immemorial, and those of Almaden since the Roman period. The beds of Monte Amiata (Tuscany) were worked by the Etruscans, who used cinnabar as a colour. But anything in the nature of real production only began between 1200 and 1300, and on a modern industrial basis in 1398. The Californian mines (New Almaden), discovered in 1499, have been worked only since 1580, and those of Peru (Mines of Huancavelica) since 1571. The Russian cinnabar-bearing mineral (at Meiji) in Hokkaido, at Hizoshi in the prefecture of Shime, and at Ugashi in that of Aomori, or as metal (at Shamoni in Hokkaido).

Other deposits of some importance have been found and worked in Japan, either cinnabar-bearing mineral (at Meiji) in Hokkaido, at Hizoshi in the prefecture of Shime, and at Ugashi in that of Aomori, or as metal (at Shamoni in Hokkaido).

Mines of less importance exist in Texas (Brewster County), at Koniah (Asia Minor), in Hungary, in Czechoslovakia (near Horwitz), in Loibethal (St. Anna), at Dellach, Reichenau, Hotschna, etc., at Reichenstein am Erzberg, in Steiermark, near Belgrad (AvalaBerg), in Dalmatia (Spizza), also in Italy (Valalta, Upper Adige), in Bosnia (Zec Planina), etc., but most of these mines are abandoned to-day. Deposits apparently exist also in Colombia, South Africa, New South

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1 The actual production of minerals in the year 1919 is said to have been, for Spain, 24,066 metric tons; for Algeria, the export of minerals reached 8,100 metric tons in 1919 and 900 in 1921. In the United States, the production for 1919 was 855 tons. For mercury, see article "Mercury"
Wales, but no recent or precise data exist about them.

Processes in the mine. — The work is carried on in galleries (at a depth varying from some dozens of metres to 600-800 metres) and is of the same kind as in other mines (see article "Miners' Diseases"). The rocky beds often require use of explosives. Among accessory work that of supporting the galleries, transport of the minerals, lighting, ventilation, lifts, pumps, etc., should be mentioned. A preliminary classification of the ore often takes place in the gallery.

Of first importance are the problems of ventilation, of lighting, of dust (if the ground is silicious) or of humidity (if the mine is very wet), of the removal of the water which filters through the soil, especially on account of the dejecta of the workmen in the galleries (danger of ankylostomiasis — see that article), although so far this infection has not been reported in the quicksilver mines. Danger is present also from noxious gases coming either from the ground itself (carbon dioxide and especially hydrogen sulphide, more rarely fire damp) or from the explosives used. Energetic mechanical ventilation may be called for at times to deal with these gases when in quantity (Monte Amiata).

Although the insolubility of cinnabar may not be — as some maintain — a sufficient reason for excluding a priori the possibility of mercurial poisoning from inhalation of cinnabar-bearing dust, yet mercurialism among cinnabar miners is very difficult to establish. This fact is due either to the temperature of the gallery which, as a rule, does not exceed a maximum of 28° C. and consequently does not cause decomposition of the sulphide of mercury and volatilisation of the metal, or to the humidity of the mineral which hinders formation of dust. At the same time, if the mine contains the metal then cases of poisoning can be found. Pulmonary lesions are also possible if the mine is dusty, rheumatism if humid; possible, too, is poisoning by arsenic, lead, or antimony.

Preparation of the mineral. — The ore is crushed (by hand or machine) and then dried by exposure to the action of the sun or the air or to air artificially heated in tunnel driers, or vertical driers, or on bricks under which hot air circulates in channels of masonry. At Monte Amiata these methods are now replaced by revolving airtight cylindrical driers. A current of heated air maintains a temperature of from 30 to 40° C. The moisture in the mineral is then reduced to about 4 or 5 per cent., which is necessary for good distillation. During drying, the temperature only reaching a maximum of 30-40° C., the cinnabar is not decomposed and the aqueous vapour given off does not contain mercury.

The dried mineral falls gradually into a receptacle from where, through sieves, it is loaded on to trucks and wheeled to the furnaces. Danger from mercury here could only be the result of accident (closeness to the furnace, presence of oxide of mercury in the ore, etc.), and, as a matter of fact, persons employed in drying in the mines of Monte Amiata show no signs of mercurialism. The sifting — not always done — only gives rise to argillaceous or calcareous dust.

The ore is next cleaned according to the size of the blocks.

Roasting. — The ore is roasted in the presence of air in furnaces with charcoal and even wood alone in the presence of air (to get rid of the sulphur) according to the following chemical reaction:

\[ \text{Hg}_2 \text{S} + 20 = \text{Hg} + \text{SO}_2 \]

Gas firing of the furnace is likely to replace the systems at present used for roasting the ore which cause a loss in bye-products valued at about 20 per cent. of the mercury present. The advantages would be a higher calorific effect, suppression of dust, more limited production of soot, regularity in heating, diminution of hand labour, etc.

The modern furnaces (Cermack-Spirek system, etc.) perfectly airtight, with a negative pressure inside and automatic fall, only deal with the crushed ore, while tower furnaces (Spirek system) deal with ore in lumps, and the revolving furnaces with very fine mineral. The hopper for charging the tower furnaces is provided with a hydraulic lute. In certain mines, however, old systems of furnaces are still employed (with subliming pots).

The mercury vapour given off in roasting under the negative pressure inside is drawn off directly from the furnaces themselves by Root's blowers, and carried at a temperature of 100-130° C. to condensers.

Condensation. — The condensers consist of shaped airtight pipes arranged in a vessel filled with water which allows of recovery of the mercury in a metallic state. As the mercury vapour has a tendency to escape from the condensers, these are linked up to a series of condensing chambers provided
with gutters (wood or masonry — at Monte Amiata, cement) which facilitate deposition of the metal. The vapours are thus chilled by water spray before reaching the storage vats.

Distillation in muffie furnaces with chalk or iron ore is very rarely done: the process with alkaline sulphide or by electrolysis is not yet industrially practicable.

**Danger.** — The slightly lowered pressure inside the Cermack-Spirek furnaces reduces escape of vapour to a minimum; but this type of furnace requires very close attention to secure regular and perfect working. Any obstacle in the proper working may give rise to serious accidents as well as unsatisfactory production.

A perfect technique, therefore, can almost completely suppress escape of fumes, but the workmen at the furnaces can inhale the vapour, especially when, through special openings at the furnace mouth, they have to stir up the ore by means of long iron rakes to assist its fall into the inside of the furnace. Failure in attention or inexperience of the workman may allow mercury vapour to escape in a larger or smaller amount.

The danger is greater at the moment of discharge if the residues are hot. At Idria the residues from roasting contain 0.00036-0.0014 per cent. of mercury, whilst at Monte Amiata none at all. Further, the residues from the furnace fall automatically into a gallery which is periodically cleaned by a strong spray of water.

The work of cleaning the pipes is very dangerous. The effect of sulphur dioxide (SO₂), of ammonia, and the radiant heat from the furnaces must also be taken into account.

**Purification.** — The distilled mercury is mixed with remarkable quantities of impurities, particles of unburnt coal, undecomposed hydro-carbons, mineral dust, cinders and water, and traces of oxide and sulphide of mercury.

Three-quarters of the upper portion of the contents of the depositing vats placed at the bottom of the condensers are made up of the “blacks” or “stupp”, whilst pure mercury occupies the floor of the chamber and is withdrawn by a tap placed below the reservoir.

The “stupp” treated with lime and submitted to extraction in Exeli furnaces yields 80 per cent. of mercury, and the residue is roasted again with the ore. The “soot” from the chimneys and the “stupp” from the pipes collected during cleaning operations are submitted to the same procedure and yield about 30 per cent. of mercury.

**CLEANING THE MERCURY**

**Filling the flasks.** — An automatic system to-day replaces the cleaning of the mercury which was formerly done by hand by means of a sponge (very dangerous work). On leaving the Exeli plant the mercury passes through a series of reservoirs connected below and of which the last is in communication with the reservoir in which the mercury is automatically weighed. It then passes to the receptacle. The process being automatic, practically all danger is removed.

**Danger.** — After condensation, besides mercury vapour, the air contains in suspension droplets of the metal in a very fine state of sub-division. Further, the workman comes into contact either with the mercury or with the “stupp”, which are important sources of poisoning. Treatment of the “stupp” or “soot” gives rise also to the liberation of ammoniacal vapour.

The most perfect technique ought to prevent as far as possible every escape of vapour, and thus ensure the highest output. Even with these precautions, however, danger is inevitable, and the factory finds itself in a chronic state of mercurialism.

The whole of the installation has generally to be cleaned once a year, and work is suspended for a month; the factory portion is cleaned once a month; the condensers, which empty into the first two receptacles as well as the rest of the apparatus, is cleaned about every two months. In the event of repairs or partial cleaning, every measure possible to prevent the escape of fumes must be taken. Before opening up the pipes and furnace good exhaust ventilation for the fumes and complete cooling of the installation should be insisted on. At Monte Amiata, for instance, the furnace is divided into two sections, and every opening should be arranged alternately in the two sections, and good ventilation for removal of the vapour which might escape at the moment of opening is maintained.

Dispersion of mercury vapour, it should be remembered, is a serious danger not only to the personnel of the factory but also for the neighbourhood, including cattle.

**Statistics**

Modern technique is in a position to reduce, and, in some measure, suppress the conditions which in times gone by
resulted in serious and fatal cases of mercurialism. The clinical picture described by Arevaca and Kussmaul is becoming more and more infrequent among those engaged in the metallurgy of mercury, but a state of slight mercurialism still exists which can affect the furnace worker in his highly skilled work so much as to oblige him to accept a lower post or even that of an ordinary labourer. There are no recent data (see also article "Mercury"), and comparison of pre-war figures with those since the war cannot be given.

In the mines of Idria, before 1886, Baaz gave 11 per cent. as the average number of workers affected with chronic mercury poisoning and states that he had seen about 500 cases in five years. Previous to that time, according to various authorities, the frequency of mercurialism was even greater. The principal Medical Officer of the Mines (Dr. Siverak) stated that in 1906, of 209 persons employed, a third only — and they the ones least exposed to the danger — could be considered as constituting a stable personnel, as the other two-thirds left the mine after two or three months' work. According to him the workmen were timorous, weak, frequently addicted to alcohol, and very often ill (morbidity: 95-104 per cent.). In 1906, of 741 cases of illness among the group of miners only 6 were cases of mercurial poisoning, whereas among 179 furnace workers there were 12.

The perfected technique, and especially alternation of employment adopted in 1896 (one month at the furnace and two months in the mines), have without doubt improved the sanitary situation. In effect, while in 1896 there were 122 cases of illness for every 100 workmen, with 2,814 days of absence, in 1908 there were only 5 cases with 145 days of absence.

In the course of an enquiry made by Teleky, severe cases of disablement from mercury were found to number only 9 (among 1,200 employed), and among 299 workmen only 19 showed slight symptoms of intoxication. At the same time the mortality of the miners was very high, especially from tuberculosis.

It is of interest to recall that cases of mercury poisoning have been reported among the members of the families of miners in Idria, especially when the children slept in the same bed as their father.

Diminution in the number of severe cases has taken place, also at Monte Amiata, where, however, it is still possible to find cases of slight hydrargyrism, which, were it not for close medical super-
vision, would disable the furnace worker for his highly skilled work and compel his transference to labouring work. Giglioli, in 1908, among 135 furnace workers examined found 20 with moderately severe symptoms; 45 had had, or still had, typical symptoms; 25 had shown distinct mercurial disorders. In 1925 Loriga and Biondi noted an improvement in the state of health of the miners at Monte Amiata. The American quicksilver mines are in the States of California, Texas, Nevada, and Oregon. Of these, 95 per cent. are cinnabar mines and the remainder selenite or tennantite, telluride, and iodide of mercury. The number of workers was very small (95 at New Idria, 35 at New Almaden). Cases of tremor, psychosis, etc., are recorded. According to Kober, the eleventh census of the United States gave 10.4 per cent. of the workers employed in the mines of New Almaden as being affected by mercury. No further information is to hand.
Special Pathology applied to the Metallurgy of Mercury

Under the best conditions of work, probably 1 or 2 cases of poisoning occur among every 100 workers; of every 3 both arduous and continuous and without doubt unpleasant, predisposes to heart affections, and the humid atmosphere to rheumatism. According to the enquiry by Giglioli, 50 per cent. of the men at the extracting works in the galleries (which may be iuraaces and bottling) showed signs of mercurialism. The furnace workers who might have been expected to show the malady in its purest form, that from inhalation of vapour
(tremor, etc.), on the contrary had a mixed intoxication with symptoms like those induced by compound of mercury. This fact is due, in part at least, to the condensation of the mercury in the buccal mucous membrane and its transference by the saliva to the digestive tract from which it is absorbed as an organic compound. Stomatitis is probably the expression (at times the only one) of this intoxication by a compound of mercury superimposed on that set up by the vapour.

Account ought to be taken also of the less typical cases of illness, which have their origin no doubt in mercury (slight mercurialism). Further, a dry rhinitis is reported among the metalurgical workers, due probably to the vapour of sulphur dioxide and accompanied by frequent epistaxis difficult to arrest.

Further, a large number of ailments are attributed to the occupation, either respiratory (bronchitis, tuberculosis) or nervous, of long duration. The number of invalids is very high as well as the death rate (from respiratory diseases: pneumonia, tuberculosis). The effect of mercury on the offspring of those suffering from poisoning and the predisposition to miscarriage should be recalled.

Zangger (1930) has noted symptoms connected with mercury, especially amongst workers engaged in distillation repairing and cleaning. He found very serious symptoms amongst workers who during several years seemed to have been immune.

**Hygiene**

The preventive measures to be adopted can be summed up as follows: Best construction of furnaces (airtightness, negative pressure in the interior, automatic feeding of the ore, etc.), constant supervision both of the action of the furnaces and the upkeep of the piping. Watch specially that no escape of vapour takes place from the upper part of the Spirek furnaces by increasing, if necessary, the thickness of the layer of ore; examine periodically the composition of the gas from the chimneys (which can besides effect a great increase in the output). If fumes do escape there would be advantage in adopting the electrostatic processes used, for example, in America for the separation of mercury from the smoke. As complete a condensation of the vapour as possible (by long U-tubes in sufficient number), followed by effective cooling, are factors of the greatest importance in preventing the escape of mercury into the atmosphere and ensuring the most complete recovery of mercury. Good exhaust fans to the Exel furnaces permit of all residues being used and condensed, and limit contact with mercury. It would, however, be useful to evolve a perfectly enclosed type of fan which could prevent escape of toxic vapour at the moment of the reaction between the lime and "stupp".

A mechanical system for the purification, cleaning, and bottling completes the series of measures of prevention on the technical and industrial side.

Seeing that the specific dangers are so great, the duration of the work of the shifts should be limited with alternation of employment for those most exposed to risk (e.g. one month for furnace work, and two months at outside work or) in the mines. There should be cloak rooms, separated from the work rooms; meal rooms, etc. The working suits should be provided by the employer and washed once a week.

Douche and vapour baths should be installed, the first for use every day and the latter once a week. At Monte Amiata the furnace workers have the advantage of using the hot baths in Sienna. For details regarding measures adopted at Monte Amiata see article by Palumbo, 1921. For personal hygiene, medical examination before taking up employment, and periodic medical examination see article "Mercury".

**Legislation**

The first statutory intervention known dates from 1665, when the hours of work in the quicksilver mines of Friuli were reduced to six per day in consequence of the effects on health.

Women under twenty-one years of age and young persons under fifteen are excluded, in Italy and in Rumania, from the work of smelting cinnabariferous ore.

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Metal Grinding and Polishing

French: Métaux (Aiguisage et polissage).
— German: Metalle (Schleiferei, Polierei).
— Italian: Metalli (Lisciatura, pulitura).
— Spanish: Metales (Afilado y pulimentado).

**TECHNICAL DATA**

Grinding, that is, giving an edge to a tool or arms, is synonymous with sharpening, and is a term used especially in connection with tools ground on a wet stone. Whetting, that is, to give the finishing touch to grinding, is a process ordinarily done on a whetstone with oil.

Polishing or glazing is making the metal smooth and bright by mechanical friction.

These two processes are very similar to one another. Generally, grinding is first started by a file or on a grindstone, dry or wet, and is finished on softer stones with oil. Similarly, polishing or glazing includes habitually a series of processes like those described; there come successively in use strong files or hard grindstones; next, moderately soft files; and then finer and finer ones, or grindstones less and less rough; the process is finished on felt or cloth mops to which very fine and soft materials are added.

For very small objects lending themselves to the process, polishing is sometimes done in rotating receptacles (drums), in which the articles are polished by reciprocal rubbing, or by the aid of polished steel balls, or again of substances slightly abrasive often combined with soap.

Only very hard metal articles, nearly always of steel, are ground; on the other hand, most metals are polished. The term "polishing" is reserved for the polishing of side-arms.

It can readily be understood that in polishing, the methods, and especially the abrasives used, differ notably according to the nature of the metal worked.

**Polishing of hard metals** (cast-iron, steel). — Ordinarily, pieces of machinery of rather large dimensions are polished exclusively on finer and finer files. Cast-iron and steel articles lending themselves to it are polished on grindstones after the roughnesses have been removed.

The grindstones are of stone, quartz, corundum, emery, etc. The grindstones made up of these last ingredients are artificial stones of which the grains, more or less fine, are united by a stratum mainly consisting of cement, rubber or resin (see article "Abrasives").

When the object to be polished or glazed has been softened by the means indicated above, it is generally subjected to softer polishing wheels of strong leather, or, better still, of wheels entirely made up of leather discs in juxtaposition and bound closely against one another. These wheels, running at great speed, act very superificially and are often dusted over with very fine emery powder or abrasive substances of only slight hardness, such as pumice, Tripoli, polishing rouge, etc. Circular mechanical brushes made up of wire and sometimes of bristles are also used. Very often the finishing is effected by means of felt or cotton.

The wheels and finishing brushes sometimes assume a hemispherical shape at the extremity of a rotating axis. The advantages of such an arrangement are that it is the only one which allows of mechanical polishing in rather deep cavities.

Finally, the mechanical wheels and brushes differ in size, form, and position, according to the nature of the objects habitually dealt with. Large metal plates are sometimes polished by hand.

**Polishing of soft metals** (copper, brass, nickel, silver, gold, etc.). — In the polishing of soft metals, grindstones of very fine grain, and brushing wheels of rubber, basil, or felt, as well as abrasive substances of slight hardness, are used: brick dust, pumice, Tripoli, washed chalk, yellow oehre, Viennese chalk, polishing rouge (which is an oxide of iron), and, finally, powder, etc. In the case of precious or soft metals, after a dry smoothing, the articles are dealt with by means of a paste prepared with the substances just named, diluted in oil or surrounded by fatty substances. Exceptionally, in goldsmiths' work use is made of a paste containing potassium cyanide.

When the articles are ornamented in relief or hollowed out, especially in workrooms for galvanoplasty, nickelering, silvering and gilding, scratch-brushing is frequently done. By scratch-brushing is meant energetic hand friction of the object to be polished by means of a kind of brush composed of a bundle of brass threads. The process is always done wet.

Another very frequent operation carried out on objects made of precious metals, or subjected to silvering or gilding is burnishing. This work, quite often entrusted to women, consists in rubbing, by means of a hand tool called a burnisher, the parts intended to be very bright. The polishing and acting extremity of this tool is made of bone, agate or, more rarely, steel.
The principal risk in polishing metals is due to dust. That can at any rate be said, and to a still greater extent of grinding. In the dust of the latter operation hard particles are met with, often siliceous which have come off the grindstones. The metal particles are here of little importance; the fineness of the particles removed favours their transformation into oxide owing to the high temperature due to the friction. In the polishing workrooms, even when done wet, the dust is often abundant and almost always injurious, whether derived from very hard abrasives like emery or carborundum or from very resistant metals.

When the polishing is done wet, or even with oil, the dust is thrown off by the grindstones and brushes: these projections dry on the ground and on the tables and the dust so created eventually gets into the atmosphere.

The "dressing" of the old grindstones and brushes and their necessary recutting from time to time is a particularly injurious occupation owing to the considerable quantity of the dust created.

Occasionally, in addition to the irritating action on the respiratory tract a toxic action is added; this is notably the case when the metals polished or the abrasive substances contain lead.

Contact with irritating substances gives rise to dermatitis, which is also caused by the fatty bodies entering into the composition of the polishing pastes, or by the solvents serving for the final scouring (benzol, methyl alcohol, benzine, turpentine, etc.).

While the figures are as a matter of fact the figures are as the result, especially is fairly frequently the cause of ulcers on the fingers and hands of polishers. These ulcers, always benign, very often take on a character recalling the "chronic holes" of tanners or ulcers of men working with bichromates.

Polishing by hand large surfaces of metal is a tiring job.

The abnormal stooping position of the polishers, and more especially of the grinders when they lie on their stomachs as is the practice in certain regions is a potent factor in the unhealthiness of the trade. In the cutlery workrooms the grinders are seated very near the ground, and the necessity of their work obliges them to be very close to the stones as they generate the dust. In polishing the workman generally stands upright and, in order to do the working distinctly what he is doing, brings his face close to the object he is polishing. When large pieces are

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**SOURCES OF DANGER**

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**STATISTICS AND PATHOLOGY**

**MORTALITY FROM ALL CAUSES AMONG POLISHERS**

<table>
<thead>
<tr>
<th>Age group</th>
<th>Number exposed to risk during a year</th>
<th>Actual deaths</th>
<th>Calculated deaths</th>
<th>Ratio of the actual mortality to that calculated</th>
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</thead>
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<td>11574</td>
<td>28</td>
<td>34.47</td>
<td>81</td>
</tr>
<tr>
<td>20-30</td>
<td>1422</td>
<td>35</td>
<td>30.78</td>
<td>114</td>
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<td>113</td>
<td>12.9</td>
<td>94.47</td>
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<td>40-50</td>
<td>316</td>
<td>7</td>
<td>5.5</td>
<td>137</td>
</tr>
<tr>
<td>Above</td>
<td>2</td>
<td>2</td>
<td>1.27</td>
<td>137</td>
</tr>
<tr>
<td>Total</td>
<td>14,874</td>
<td>88</td>
<td>85.02</td>
<td>101</td>
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</tbody>
</table>
The data concerning the frequency of certain diseases among polishers has reference especially to cases of saturnism and diseases of the skin. Both in Austria and Great Britain numerous cases of lead poisoning have been reported among polishers of metal capsules made of tin and lead (the dust from this metal, capsules contained from 1.4 to 25.6 per cent. of lead). Other cases have been described between 1914 to 1918 in Great Britain among the polishers of copper articles (containing 1.5 per cent. of lead); 19 cases in Birmingham, of which 7 were due to insufficient locally applied exhaust ventilation to remove the dust; in Prussia among the polishers of goldsmiths' work from the use of chrome red and yellow and a substance with a lead basis (white lithopone). In 1902 an examination was made in Great Britain of 210 polishers, of whom 16 showed signs of lead absorption (see Annual Report of the Chief Inspector of Factories for the year 1915, page 388).

During an enquiry dealing chiefly with Sheffield workshops, Macklin and Middleton examined 1,153 workers and found a considerable number of workers regarded as suspects, however, were classified as follows after diagnosis: 221 cases of bronchial-catarrh (19.16 per cent. of the total number of workers examined), which affected chiefly glazers and dressers exposed to inhalation of silica, as well as other dusts. The latter play a role in the production of the respiratory disease, which is in direct proportion to their concentration. 146 cases of bronchitis (12.6 per cent.) affected chiefly textile machinery grinders and dressers. 76 cases of pulmonary catarrh occurred, chiefly amongst wet sandstone grinders aged sixty to sixty-five. This lesion is regarded as a consequence of silicosis which affected the workers in the proportion of 73.97 per cent. Signs of fibrosis became apparent in the majority of cases during the first five years of work, increasing progressively to the end of the twentieth year, at which period almost 80 per cent. of the workers were affected.

The frequent incidence of cases of fibrosis amongst wet sandstone grinders is related to a very high concentration of dust particles in the air (2,000 to 12,000 (reckoned with Owen's konometer, averaging 3 to 6,000) per cub. cm.). For details see the report of these experts (published in London by H.M. Stationery Office, 1928).

In Germany, Teleky, Lochkemper, Bosenthal-Deussen and Derdack studied (1958) troubles due to dusts amongst metal grinders. According to the research engaged in by them, sandstone grinding is quite as dangerous as the dry method. The quantity of dust liberated is considerable, since it is reckoned that in the space of four weeks the grindstone is reduced in diameter by 50 per cent. on an average. Thus, despite humidification, large quantities of dust become dried and liberated. Clinical symptoms of the disease — and particularly radiographic examinations — showed serious pulmonary lesions due to quartz dust, lesions occurring among sandstone grinders after the first four or five years of work. Polishers using chalk showed hardly any pulmonary lesions, whilst with the use of pumice stone slight modifications occurred after a fairly long time; grinding on artificial corundum grindstones is less harmful than grinding on sandstones; pulmonary changes are only noted in this case after a lapse of twelve or thirteen years and are not particularly severe, even after thirty-two years. The artificial stone wears out much less rapidly, the dust liberated coming rather from the object in course of being sharpened than from the grindstone.

An enquiry made in Belgium by the Medical Inspector of Factories in 1912 in a factory where articles were made of an alloy of tin and lead showed that of 15 persons engaged in polishing 7 showed slight symptoms of lead poisoning.

In Switzerland, K. Amman (1923) studied 15 cases of pneumoconiosis among polishers and made four autopsies. In 9 workmen X-ray photographs showed chalico-siderosis; in the others the hilum shadow was well marked; 4 had died of tuberculosis and 2 were suffering from it. Amman considers that cases of pure chalico-siderosis are very rare, and that the majority of the cases of pneumoconiosis end in tuberculosis. Enquiry made by him in a factory in Zurich showed that, between 1907 and 1916, 29 deaths had occurred among the workers, of which 20 were the result of tuberculosis (the workers' ages varying from 20 to 64 years). Prognosis is very bad; twenty years' work incapacitates the workman. Between 1900 and 1922 the labour turnover in a factory employing 25 polishers reached the figure of 236, of whom 18 had died. In the last few years (1917-1920) every year one workman died, and (1921-1922) two polishers per annum who had worked respectively for ten, twenty, and forty years had died with symptoms recalling silicosis. Amman is of opinion that chalicosis should be treated as regards compensation in the same way as silicosis.

Skin diseases also have been frequently reported, especially in Germany (eczema, ulcers, etc.), from the use of denatured alcohol and turpentine substitutes, either among polishers of ordinary metals (copper, etc.) or of gold, silver, etc. In Bavaria and Prussia cases have also been reported of blepharitis and conjunctivitis induced by the vapour from the polishing solutions containing turpentine substitutes; in Austria (1913) cases of poisoning by carbon monoxide due to escape of gas from piping and soldering irons (in the polishing and mounting department in a cutlery factory).

Skin diseases are sometimes caused by the benzine or benzene used by workers to remove the last traces of grease.
Among some of them alteration of the blood, characteristic of the action of benzene (lymphocytosis, diminution in the number of red blood cells), has been described (Teleky).

An enquiry by Agasse-Lafont, Domoulines and Heim (1915-1922) gives interesting information on pneumoconiosis among metal polishers. It related to a group of polishers of steel, iron and copper, aged 33 to 59 years of age, with a duration of employment of twenty to forty-five years, and to another group of tin polishers aged 20 to 44 years and duration of employment of nine to twenty-four years.

Clinical examination showed all to be subject to coughing with more or less abundant expectoration; in 30 per cent. these symptoms were moderate, and severe in the others. Physical signs were slight—localised especially at the apices; but definite pulmonary lesions were only made out in 20 per cent. of the subjects. There was no history of haemoptysis. Radiography, on the other hand, brought out very clearly a fibrosis of the tissues due to the dust which clinical examination alone quite failed to do.

The proportions of lungs affected numbered 69 per cent. and sometimes the apices, sometimes nodules situated in the upper lobe or along the bronchi (40 per cent. in the upper bronchi) were quite opaque. The mediastinum was relatively little affected, but in 15 per cent. of the cases showed an abnormal shadow similar to that of sclerotic lesions. The shadows from the pulmonary glands, bronchial and mediastinal, were rather like those of tuberculous lesions of fibrotic character, or in process of cicatisation.

The polishers of the lead tin alloy are not only exposed to fibrosis of the respiratory tract and parenchyma by the dust like other polishers, but are exposed also to the risk of lead poisoning. Radiological examination showed the same lesions as in the other polishers, the signs of lead absorption and lead poisoning were also very frequent (70 per cent. had a blue line, 40 per cent. colic, 30 per cent. tremor, 70 per cent. polychromatohil red blood cells, 50 per cent. basophil granulations).

Caffaratti has reported ocular lesions amongst grinders, which in Turin factories amounted to 83 per cent. of all ocular affections noted. In general the victims of these lesions had worked without protective glasses.

Hygiene

In addition to all the hygienic measures for workrooms and persons employed common to all industries, emphasis must be laid on processes for the capture and removal of the dust produced in the polishing processes. The reader is referred to the articles "Abrasives", "Iron. Pig Iron and Steel Industry", "Stone Industry", "Dust, Fumes and Smoke", "Glass Industry", "Timber Industry", etc., in which the best measures are described in detail for protecting the workmen against all dusts generated in the course of ordinary work; here questions concerning the polishing workrooms only are dealt with.

Every installation should comprise a fan (generally a suction fan), a dust collector and a hood for enveloping the tools in the best way possible.

In the case of emery wheels, when the work is good on the anterior face of the crown the covering hood adapts itself perfectly to the exhaust duct, and suction alone suffices as only a small part of the crown of the wheel remains uncovered. If work, however, has to be done on the upper part of the wheel, a hood should be used with movable sectors which can be adjusted to the necessary positions and the dust collected in a funnel-shaped receptacle placed at the back, but which can be turned towards the wheel at will. If the suction at the forward sides of the wheel is stopped, the draught at the back will be increased.

Although the rather special conditions of polishing shops, the variety of the work done, the smallness of the workrooms, the expense of installation, and the dislike of modifying the custom of the trade make conditions iminical to good systems of locally supplied exhaust ventilation for the capture and removal of dust, the advantages of ventilation are beginning to be appreciated by those interested, and marked progress has often been recorded by factory inspectors.

Experts advise that a fan of low power be not used, because if its speed will have to be increased, with the liability to cause an accident. The moving air leaving the fan can be used and blown again, for example, into the aspirating duct of the hood over the cleaning bath, or into the closets to help remove smells.

Besides the advantages to the workpeople from successful removal of dust, the installation of exhaust ventilation provides considerable material profit when it is a question of collecting metallic dusts of a definite value (copper, silver, gold, etc.). When this is the case, the dusty air from each tool is drawn away by piping connected up with a fan of large drawing power and low pressure with the introduction of a flannel filter between the machine and the fan.

Removal of the dust in burnishing should not be allowed to incommode the workpeople, who require great freedom of movement at every part of the wheel. Consequently, ordinary
hoods cannot be used if protection has to be limited to placing in front of the workman a sheet iron cupboard leaving the front quite free. The dust and fibres coming off the wheels or mops are stopped by a kind of movable sheet iron plate which the workman can bring almost right up to the wheel. Naturally, in the burnishing of very large pieces this cupboard would have such large dimensions that the draught would not be sufficient to take away the dust obstructing the piping, and it would then be necessary to connect up the back of the sheet iron cupboard to a fan of the appropriate strength.

Workers should be prohibited from greasing the wheels with oil or applying Vienna lime in powder form to the surface. The employer would be well advised to place at the disposal of the polishers cakes ready prepared of lime and grease thoroughly mixed, and it should be possible for the men to ride on the stone without dust being given off.

Authorities on the subject recommend also periodical medical examination, and regulation of working hours.

LEGISLATION

In France, the employment of young persons of less than 18 years and women in the polishing and grinding of metal is forbidden, as well as in the manufacture of grindstones and polishing wheels. In the Netherlands employment of women in the polishing of metals is also prohibited, and in South Africa that of young persons of less than 16 years (dry polishing). At the same time the technical experts point out that if all premises would put their house in order in the manner indicated by hygiene experts (removal of dangerous dust) the prohibition laid down by legislation could be withdrawn as the cause necessitating it would itself disappear.

In Great Britain regulations have been enacted: the Grinding of Metals (Miscellaneous Industries) Regulations, dated 2 September 1925, for the grinding and glazing of metals or the cleaning of casings (Statutory Rules and Orders, 1925, No. 904); the Grinding of Cutlery and Edged Tools Regulations, dated 26 October 1925, for grinding or glazing or processes incidental to grinding or incidental to the manufacture of cutlery, edged tools, swords, bayonets, files, saws, ploughs or other cutting or piercing implements of iron or steel (Statutory Rules and Orders, 1925, No. 1089). For details see the Legislative Series, 1925, G.B. 8 (published by the International Labour Office).

Compulsory notification of dermatitis (eczema, ulceration, etc.) occurring amongst metal polishers is also required in the Netherlands. Phthisis among grinders (aiguiseurs) is a disease for which compensation is paid in Canada (Ontario).

Special legislation is required for workshops in which metals are manipulated which might set up poisoning (lead).

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Metallisation by Pulverisation


The advantages of protecting metal surfaces against the action of atmosphere and of corrosive substances have for long been recognised. At first, application of a layer of paint or varnish to the metallic surface was practised; later use was made of a fine metallic layer which could not be attacked by the oxygen of the air or by acids. Thus arose the method of coating with lead, zinc (galvanising), tin, obtained by means of a bath of molten metal or by an electrolytic process.

Modern technique has introduced other methods, such as electroplating, see articles "Electroplating", "Copper", "Nickel", etc.; sherardisation (invented by Sherard Cooper) for the zinc-plating of objects, which are made to revolve in a cylindrical receptacle, hermetically sealed and brought to a temperature of 400° C., containing a mixture of zinc dust (zinc powder, a by-product in the zinc industry), fine sand and a small quantity of naphthalene (as a reducing agent); calorisation, with a deposit of aluminium, which is secured by means of a calorising mass composed of aluminium, alumina and ammonium chloride, this mixture being heated to 850-900° C. in a revolving furnace; and finally the Schoop process, modified and improved, consisting of the violent projection of finely pulverised metal on to the surface to be coated.

The "pistol", invented in 1910 by Schoop, of Zurich, consists essentially of a compressed-air blowpipe, into the central nozzle of which is inserted a metallic thread set in motion by a compressed-air turbine which can attain a speed of 30,000 revolutions per minute. The metal thread is melted as soon
as it reaches the flame; it is pulverised by the expansion of the air and projected with force onto the object to be metallised. The small turbine is set in action by the air, which serves to feed the blow-pipe. The Schoop Pistol can be used with various gases: oxygen and hydrogen, oxygen or compressed air and acetylene, or illuminating gas.

The fine metallic particles are chilled by the expansion to such an extent that it is possible to metallise objects made of cement, plaster, wood or cardboard. The air pressure can reach an average of 3.5 kg. or even 5 kg.

The metals most commonly used are zinc, aluminium, copper, lead, tin, nickel and many alloys, of which the melting point is about 700° C. For certain very volatile metals, the great loss from evaporation is lessened by lowering the pressure of gas. This pressure is, however, diminished by nearly 50 per cent. in the new models of the Schoop pistol.

For pulverising certain very refractory metals (tungsten, molybdenum), use is made of a pistol consisting of an electric arc playing between two metal threads which are pulverised. There is yet another model of the "enamelling pistol", fed by pulverulent metal; this is provided with three ducts for the gaseous mixture, compressed air and the metal. One part of the compressed air is directed towards the burner and the other towards an injector; aspiration of the metallic powder takes place into a reservoir and projection of this powder across the gas flame. The use of oxygen avoids the reduction of the lead compounds used. The enamel may contain colouring matter if necessary.

The Schoop process, although recent, is in general use. Many objects of various dimensions are metallised with zinc, aluminium, tin, etc., either by means of very complicated fixed machinery or portable apparatus, in order to protect them against oxidation or attack from liquids and vapours, or again as a method of decoration. Lead is used for apparatus intended for the chemical industry and for fabrics intended for protection against X-rays and radium rays. Bridges, roofs, boilers (zinc), and the hearths of locomotives (aluminium), brewing vats (aluminium), aeroplane wings, balloon envelopes, etc., are all metallised in the same way. Before metallisation takes place, the different metal objects require to be scoured; this is now effected by means of sand (see article "Metal Grinding and Polishing"). The workman conducting this operation stands in a compartment separated from the objects to be scoured by a partition of glass.

**Sources of Danger**

There is a risk of burns, not only for the workman, but also for persons passing by the apparatus. The burns, mostly due to incompletely airtight apparatus, are very deep and severe, as the molten metal is projected under great pressure. The lesions are situated especially on the face (eye), and on the upper and lower limbs.

On account of the heat given off from the apparatus, the workman is inclined to take off garments, thus rendering himself liable to injuries and burns on other parts of the body. The metal is even projected on to the walls and the floor of the workroom, so that dust may arise.

Oxidised dusts arising from the condensation of the metallic vapours are the more finely scattered the higher the temperature to which the metal has been raised and the more rapid the cooling. Their power of penetration and absorption is therefore considerable, giving rise to risk of poisoning in the presence of dangerous metallic dusts (especially lead). Thus cases of poisoning have been reported after only a few hours' work when lead has been projected by the pistol and adequate measures of protection have not been taken.

Eibel notes ear trouble due to the compressed air. In 1924 the Medical Inspector of Factories in Great Britain reported four cases of saturnism, even although the metallisation had taken place in a well-ventilated workshop and the operator had worn breathing apparatus. It would appear that the latter could not have been effective. In order to prevent poisoning, it is necessary that a positive pressure of air should be maintained inside the mask and this can only be secured by means of compressed air.

In a German factory (1923-1924) eight cases of saturnism were reported, and one case in a factory in Schleswig.

The Medical Inspector of Factories in Bavaria (1927) considers that health conditions depend on the properties of the metal employed. In the Schoop or Meunier processes the metallic mist formed may penetrate into the respiratory tract, especially when the workman takes up an awkward posi-
tion or when he is obliged to bring his face near the object to be coated. Hence the risk of saturnism when lead is used or poisoning from zinc when zinc is in question, etc. Medical literature has brought to light several cases of poisoning of this kind, but the medical inspector has not met with them, because of the relative infrequency of this work in Bavaria. At the same time, statistical data on the subject are few. Eibel insists on the risk of "metal fever", because the metal is projected into the surrounding air, either in a very finely powdered form or in the form of vapour at a high temperature (lead, zinc, etc.). Finally, the danger of scouring with sand ought not to be overlooked.

HYGIENE

Adequate preventive measures ought to render it easy to avoid the dangers presented by metallisation: cleanliness of workrooms, use of apparatus perfect from the technical point of view, and provided, where necessary, with an adequately protective envelope; protection of the workers against the action of fumes and metallic droplets suspended in the air, by means of masks, goggles or screens. When large objects are handled, even if the operation takes place in the open air, the workman should be provided with a mask and with working clothes. Articles of moderate dimensions can be treated under efficiently ventilated hoods, and small pieces (bolts, rivets, etc.) should be metallised in completely closed revolving drums.

The worker should be protected during scouring by means of a mask supplied with a constant stream of fresh air. It would, however, be better, not only in the case of metallisation but also in that of cleansing, if such operations were undertaken either in special cabinets or in enclosed places provided with fans for collecting and directing into special receptacles the dusts given off.

No statutory regulations on metallisation exist.

BIBLIOGRAPHY


Methyl Acetate


Methyl acetate (formula C₃H₇O₂C₂H₅) is present in wood spirit (crude methyl alcohol) and in pyroligneous acid. It is prepared by distilling a mixture of methyl alcohol, acetate of potassium, and sulphuric acid. The distillate is dehydrated by means of calcium chloride and then again distilled.

Methyl acetate is a colourless liquid with an agreeable smell, boils at 57° to 58° C., and is soluble in water, alcohol and ether.

It is used as a solvent in collodion varnishes, etc., and with a view to this it is usually mixed with acetone. Pathology is similar to that for methyl alcohol (see that article).

Methyl Alcohol

(Wood Alcohol)


PROPERTIES

Methyl alcohol, when pure, is a colourless liquid, with a faint alcoholic odour, boiling at 66° C., burning with a non-luminous flame, solidifying at a very low temperature, and melting at —94° C. Its formula is CH₃OH. It dissolves in all proportions in water, alcohol, ether and chloroform. Its specific gravity is 0.7984 at 15° C. It is much used in industry, being a good solvent of fats, oils and resins. Heated with lime or oxidising substances it readily yields formic aldehyde and acetic acid.

INDUSTRIAL PROCESSES

Methyl alcohol is obtained from the dry distillation of wood and as a by-product in the manufacture of acetic acid.

The wood is distilled in steel or iron retorts placed in a brick furnace provided with a door which can be hermetically closed. The vapour of distillation is carried to a condenser, whilst the furnace gases are usually carried into the hearth to be burnt. The
liquid product of distillation generally contains plenty of water, acetic acid (6-8 per cent.), methyl alcohol (1-5 per cent.), acetone (0.1-0.4 per cent.), and a little tar. After separating the last named the liquid is saturated with lime, calcium acetate being obtained, which is then dried in the furnace beside the retorts in order to utilise the available heat.

The liquid is mixed with about 2 per cent. of methyl alcohol and distilled in a rectifying column apparatus. Crude methyl alcohol is obtained which turns reddish brown in the air and contains about 80 per cent. methyl alcohol, 10 to 14 per cent. of acetone and other slight impurities — acetic and formic aldehydes, furfuroil, pyridine, ammonia, etc.

They are purified by dilution with water, decanting, after lying some days, from the oily layer of tar which collects on the surface; treatment then takes place with lime and is followed by complete distillation. The distilled product is mixed with 0.1 to 0.2 of sulphuric acid and rectified by collecting separately the tailings (rich in wood oil and ketones). The portion which distils between 62 and 65° C. is used to denature ethyl alcohol and to make formic aldehyde. A third portion (about 25 per cent.) constitutes pure methyl alcohol, which is carefully distilled between 65° and 66° C. and serves for the preparation of synthetic organic products.

Purification is effected by distillation in presence of a little hypo-chlorite of calcium (elimination of acetone, formation of chloroform) or in converting methyl alcohol into a compound ether which is then saponified. Distillation and rectification follow.

Other processes of less importance need not be described except that of direct synthesis which is already applied industrially in Germany: methyl alcohol is obtained by passing a mixture of carbon monoxide and hydrogen at 500 atmospheres pressure over a catalyst (metallic oxides) heated to about 400° C. The gaseous mixture is obtained using steam as the starting point (see article "Gases and Fumes").

The alcohol so obtained also forms the basis for the preparation of dimethylaniline and other intermediate products used in the production of artificial dyestuffs and for the manufacture of formaldehyde.

USES

Among the numerous uses of methyl alcohol are the preparation of formic aldehyde and methyl derivatives (dimethylaniline, methyl chloride and bromide, etc.), the manufacture of aniline colours, etc.

As a solvent of resins and as an important ingredient, it is used in the preparation of lacquers, varnishes, dyes, starch paste, etc.: in the hat industry, making of artificial flowers; in the brewery industry (special varnishes for the vats); in polishing furniture and wood generally (pianos, pencils, canes, toys, etc.).

It is further used: as a solvent of acetate of cellulose, collodion (mixed with acetone or benzol or both together), etc.; in aniline colours, the drying of which it facilitates; to denature ethyl alcohol (mixed with pyridine, etc.); to clean machines (e.g. the letters of typewriting machines, etc.).

SOURCES OF DANGER

Danger arises both in the manufacture of the substance (when escape from the apparatus occurs) and during its use (from the evolution of fumes), but that from ingestion is very rare and accidental on the industrial side.

If in the course of manufacture the doors of the retorts are left with the slightest aperture owing to their being split, or do not close hermetically, the gases and vapours which escape constitute at the same time both a loss in output and a danger to the workers (from irritation of the mucous membranes especially).

The use of methyl alcohol as a solvent (of colours, resins, etc.) sets free vapours potent for serious harm to the workmen. Thus, in an American factory for making artificial flowers, at a distance of two metres from the point at which dipping and dripping was done, 2 volumes of alcohol per 10,000 volumes of air was found in the atmosphere.

TOXIC ACTION

Views vary as to the toxicity of methyl alcohol. Some authorities regard it as less toxic than ethyl alcohol, because, in their opinion, toxicity increases with the number of atoms of carbon (Rabuteau's Card), while others take the view that methyl alcohol is an exception to the law in question and is more harmful than ethyl alcohol. It is certain that in massive doses the latter is more toxic than the former, but in small and repeated doses it is considerably less so than methyl alcohol. This contradiction is explained by the fact that accidents due to methyl alcohol take much longer
to develop and elimination by the kidneys is much slower; as a result symptoms of poisoning are slower in appearing themselves and more severe in the long run than are those caused by ethyl alcohol. Further, account must be taken of the fact that in its industrial use methyl alcohol always contains impurities which certainly play a part in the production of the reported lesions. Thus, for example, the presence of pyridine bases and furfurol (used as a solvent in the manufacture of varnishes and protective coats) deserves careful study.

English methyl alcohol contains 2 per cent. of wood spirit, 1 per cent. of essence and 97 per cent. of alcohol. Special industrial spirit contains 3 per cent. of wood spirit and 97 per cent. of alcohol. Mineralised methyl alcohol contains 95 per cent. of alcohol, 4 per cent. of wood spirit and one-half per cent. of essence and is coloured by methyl violet (P. White).

In Germany, according to Koelsch, the wood spirit used for denaturing purposes contains, among other things, 50 per cent. of methyl alcohol, 25-30 per cent. of acetone, and 7 per cent. of amyl acetate and other impurities. Colombia spirit contains 95 per cent. of methyl alcohol and often takes the place of turpentine.

The toxic dose of methyl alcohol is difficult to fix. Loewy has found in the air of 8 workrooms from 0.005 to 0.06 per cent.; in 4 other workrooms a content of from 0.1 to 0.5, and among 4 others again 1 in which it varied from 0.1 to 0.622 per cent.

A content of 0.15 per cent. has not affected animals appreciably after twenty-four hours.

Brückner studied chronic poisoning experimentally in 1924, and he was even led to enquire whether the lesions described by authors before him were really to be attributed to methyl alcohol. The number of fatal cases of occupational origin is very small. Brückner considers there have not been more than 20 in the whole of Germany.

Methyl alcohol, according to this writer, is said to be an industrial poison which plays a rôle no greater than several other alcohols and other organic substances used as solvents in industry.

**Statistics**

Figures as to the frequency of poisoning and their sequelae by methyl alcohol cannot be given. Though acute poisoning is most frequently the result of ingestion (in 1904, for example, Buller and Wood collected 92 fatal cases and 156 cases of blindness culled from American literature), such poisoning occurs very rarely industrially (it may be met with among French polishers). Generally it arises from workpeople tasting denatured alcohol.

From the point of view of industrial hygiene, the cases of poisoning caused by alcoholic vapour are of greater interest. Nevertheless, apart from local signs of irritation of the skin and mucous membranes, it is often very difficult, it must be admitted, to attribute large quantities to health to alcohol itself rather than to the heat, benzine vapours, turpentine and other volatile substances present in the air, which would undoubtedly increase the injurious effects of the work done under the particular conditions.

Among the cases described in literature there may be mentioned one of Colburn's, in which methyl alcohol used for cleaning furniture had set up bilateral optic neuritis with marked diminution of vision; the very severe cases quoted by Koelsch among barrel cleaners and furniture polishers; two cases of Buller and Wood; cases of Schappringer, as well as those of Giftord, of transitory blindness from the use of methyl alcohol in dissolving colours; those of Schweinitz affecting a boat painter; of Herbert, a cooper; of Philipp, etc.

In America, Baskerville assembled details of 64 cases (in 1913) due generally to the inhalation of methyl alcohol. In 1914, Loewy made enquiry among persons employed in the manufacture of large quantities of methyl alcohol. From the replies of 40 works surgeons, he found that injury to health was quite of secondary importance. In fact, 34 doctors had seen no effects which they could attribute to methyl alcohol; only two cases of dermatis were known.

Koelsch has described (1921) cases of poisoning amongst doctors from fumes liberated in course of disinfection; a case of a woman in a boot factory, illness being contracted from a paste made up of cellulose or resins dissolved in methyl alcohol, acetone, amyl acetate, benzine, etc. After application the paste is allowed to evaporate leaving a protective layer against moisture, and giving certain elasticity to the boot.

According to Hamilton, methyl alcohol is said to be in a very special sense an "American poison", because the United States alone have more cases of poisoning than all other civilised countries put together. This is explained by the fact that nearly always pure methyl alcohol is used, whereas elsewhere it is denatured ethyl alcohol. Cases are most frequent in the painting industry and in the making of felt hats, artificial flowers, etc.

**Symptoms**

Very varying opinions are held as to occupational intoxication by methyl alcohol. Rambousek speaks of violent poisoning by the vapour with acute irritation of the mucous membranes, cough, etc.; in very severe cases, he
speaks of having detected bronchitis, headache, vertigo and tremors. Roth (1913) cites cases of intoxication with amblyopia, blindness and optic neuritis. Factory inspectors describe frequent headaches, vertigo, conjunctivitis, and visual affections as set up by methyl alcohol, especially during the war when it was used for preparing paints (Koelsch).

According to Koelsch, methyl alcohol is an important industrial poison having both a local and general action. Locally, it irritates the mucus membranes of the eyes, nose and respiratory passages, and may even set up fatal pneumonia. Absorbed internally, it sets up headache, vertigo, gastric trouble, nausea, and affections of sight which may even result in blindness. Ocular troubles begin with more or less serious diminution of vision followed by amblyopia, dilatation of the pupils (which no longer react to light), difficulty of ocular movements and blindness. Amblyopia may last 20 to 40 hours, but it is characteristic that, in severe cases, the lost sight becomes normal again before completely disappearing (Natanson). It is a question of oedema and degeneration of the ganglion cells: parenchymatous or interstitial neuritis of the optic nerve.

Irritation of the conjunctiva with follicular hypertrophy occurs among polishers set up by evaporation of the methyl alcohol from the varnishes used. The number of cases of conjunctivitis has certainly increased (statistics of Haselbery, Walker, Overweg, etc.). This danger presents itself also in silk dye works where methyl alcohol is used as a solvent for aniline colours.

The skin (forearms and fingers) is affected by lesions which may become eczematous, involving incapacity for work (for 9 to 30 days as reported in a walking-stick factory in Germany in 1919).

The symptoms in cases of very severe general intoxication with fatal issue are: rapid and marked drop in temperature; rapid breathing, followed by retardation until stoppage occurs; acceleration and slowing of the heart’s action (irregularity, intermittency); gastric congestion with haemorrhagic diarrhoea; convulsions, paralysis, loss of the reflexes and of sensation, nystagmus, mydriasis, and visual hallucinations. These fatal cases have occurred notably among workmen who had worked in vats in extremely confined spaces and had breathed vapours arising from the evaporation of large varnished surfaces (breweries, copper refineries, etc.). Very severe cases have even been reported amongst hat finishers and polishers of wood.

Hygiene

Among the hygiene measures to be adopted, only the following most important ones are mentioned:

(a) In the processes of manufacture, every leak in the doors of the retorts and every escape in the piping should be repaired. The workrooms should be well ventilated. Non-condensed gas should not be burnt under the retorts but under the furnace. All fire and hot cinders in the heaps of dust and refuse from the hearths should be extinguished (fire and explosion risk). A good draught for the furnace gases should be maintained by utilising a conoe or a cowl (controlled by a valve) coming from the main stack, and separate from all the other pipes connected with the retorts. Safety valves may also be used in each pipe passing from the retorts to the outside air. Such precautions will prevent all danger to the persons working in proximity to the retorts. During cleaning operations, valves should be closed to prevent entrance of gas from neighbouring retorts. Mention should be made of the fact that at the moment the doors of the condensers have been opened before the coal has completely cooled, very severe accidents have occurred (from spontaneous combustion of gases). But if the coal is kept for 24 hours in the cold and then left for 48 hours under covered sheds, ‘prior to transport, practically all risk of fire on trucks or boats is avoided.

The acetate of lime should be removed without exposing the workmen to high temperatures (in summer 30-100° C.); clogs should be supplied because the temperature of the floor on which they have to stand may be high. Passage ways or platforms should be arranged if possible. It is preferable to erect the dryer near to the hearths and to lead the heat and concentrate it under the floor of the furnace before it reaches the outer air.

In the distilling plant the condensers should not allow any uncondensed gases to escape. If there is likelihood of any being present they must be led to the outer air. Vats should be provided with covers or be guarded by railings to prevent any chance of a workman falling in. All risk of fire from sparks flying from electric motors must be avoided. When anhydrous vapour is to be feared, sparking cage motors should be used, instead of
those worked on the monophase system. Escape of excess of vapour into the distillation room must be avoided at all costs. This danger is especially great in winter when all windows are closed.

Only electric light should be used—neither torches nor lanterns should be allowed—and the electric lights should be of the safety kind.

Artificial light is always necessary for cleaning and repair operations. The breaking of an electric light has often been the occasion of an explosion—the filament igniting the gases present. Kerosene lamps also have caused fires.

The distilling apparatus is usually freed from accumulations of tar once every two months. At these times, the workmen are liable to suffer from amblyopia. They should wear effective box respirators. The tar is generally collected in receptacles placed in the ground and these are often left uncovered, thus favouring evaporation and giving rise to loss as well as constituting a danger. These receptacles should be covered, allowing, at the same time, for good ventilation inside them, or they should, at any rate, be situated at some little distance. Barrels or drums are often filled automatically by means of India-rubber piping, but the vapour given off when the alcohol enters the receptacle diffuses into the workroom and constitutes a danger for workmen in the vicinity. The fumes should, therefore, be led outside.

(b) During use. The workman should be protected against the vapours of methyl alcohol by a well-arranged system of localised exhaust ventilation (e.g. in the dyeing of flowers, work to be effected under a hood provided with local exhaust) or by placing the articles to be dried in a separate well-ventilated room. Certain substances which are mixed with methyl alcohol to make varnishes or protective coats should be replaced by others, e.g. in the making of pencils: for the final coating, pyridine (4 per cent.) should be used instead of benzine. This process has given good results in American factories and has eliminated at the same time all injury attributable to methyl alcohol. In a German walking-stick factory, eczematous ulceration was probably set up by traces of carhoic acid and formaldehyde contained in the alcohol. In the same way, acetic and benzol are often present in some solvents used in the doping of aeroplane wings, manufacture of motor cars (e.g. “titane spirit,” used as a solvent for acetate of cellulose in the aeroplane industry in the Netherlands (1916) contained methyl alcohol, acetone and 40 per cent. benzol).

An arrangement between the Health Office of New York and the brewers in that city resulted in the suppression of the use of methyl alcohol for coating the interiors of vats. Nevertheless, masks and goggles are placed at the disposal of the workers. Limitation placed on the use of methyl alcohol is said not to be necessary: preventive measures suffice, and these, according to the experience of the New York Health Office, should be applied when the denatured alcohol contains more than 5 per cent. of methyl alcohol.

These measures are summed up as follows:

1) Ventilation should be installed for the removal of vapour in all workrooms where one part (in volume) of methyl alcohol is found per 10,000 volumes of air.

2) All receptacles serving to hold alcohol should bear a label “Methyl Alcohol—Poison!”, with skull and cross bones.

3) When methyl alcohol is handled directly by the workman, impermeable gloves should be supplied which should be maintained in good condition.

4) When it becomes necessary to go inside one of the receptacles, vats or distilling apparatus containing alcoholic vapour, the workman should be provided with an effective breathing respirator or with other means of protection allowing pure air to enter through the mask. All vats, barrels or receptacles of whatever kind containing methyl alcohol should be provided with hermetically closing lids.

5) When methyl alcohol is used in any industrial process whatever, a printed cautionary placard should be posted up in all workrooms calling attention to the danger. (This notice is to be drawn up by the State Department of Factory Administration and should be distributed free.)

6) A ledge or platform should be erected round every furnace for drying acetate of lime, arranged in such a manner that the workman can from time to time remove the superheated matter.

LEGISLATION

Ill-effects set up by methyl alcohol are compulsorily notifiable in the United States, in the States of Massachusetts, New Hampshire and Pennsylvania, and in the Netherlands. They come under the-
Workmen's Compensation Act in Finland and in the United States (Minnesota, New Jersey, New York, and Ohio).

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Methyl Bromide
(Methyl Bromic Ether; and Monobromo Methane)


CHEMISTRY

Formula: CH₃Br. A halogen substitution product of the aliphatic series, of which the specific gravity is 1.732 at 0° C. and the boiling point about 45° C. A gas at ordinary temperature, it liquefies easily at 0° C. and appears then as a mobile liquid, colourless with a pleasant ethereal smell but not very penetrating; the smell of the commercial product is more penetrating because of the presence of impurities such as oxide of methyl or alkaline bromides. It is extremely volatile; mixed with air it can give rise to explosions.

PRODUCTION

It is obtained by heating (at about 190° C.) bromide of sodium or potassium with methyl alcohol and sulphuric acid. The hydrobromic acid given off combines with the alcohol to form methyl bromide. It can also be obtained by heating the carboxylic com-

pound As (CH₃)₂(CHOH)₂ Br, or by mixing methylic alcohol with bromide of potassium and distilling some days later.

USES

Its use is rather limited; it is used in the chemical industry in the preparation of methylic compounds; in colour manufacture in making colours from methylated tar, blue colours derived from aniline red and the greens from aniline violet; in the pharmaceutical industry especially in the preparation of antipyrin.

CAUSES OF POISONING

Cases of poisoning have arisen almost exclusively in the manufacture of antipyrin. Those persons are most exposed to risk who prepare the methyl bromide and rather less so those who methylate the pyrazolone. The process is carried out either in a closed room — naturally more dangerous — or in the open.

In the regular course of production and use there is not now any evidence of the toxicity of methyl bromide. Use of the compound, however, and of its derivatives always presents a latent danger. Although the measures adopted universally in industries using this product have limited the risk of poisoning, it should be borne in mind that the frequency of poisoning is in direct relation to the extraordinary volatility of the product. Careless or accidental overflow in the processes can allow of the rapid formation of large quantities of vapour in the receptacles and pipes and give rise to explosion or escape. Further, as a result of this great volatility considerable quantities of the vapour can make their way into the workrooms even if the apparatus leaks only slightly. Lastly, and for the same reason, escape of the product can enrich the atmosphere so rapidly with the vapour that in the case of accidents the workpeople have already inhaled appreciable quantities before realising the danger and making good their escape. The risk is all the greater because the workmen can readily become acclimatised to the smell of this product which, although penetrating, is often masked by the other numerous odours present in the workroom.

TOXIC ACTION

The minimum toxic dose for man has not yet been fixed. It seems,
however, to be very small as poisoning has resulted in a certain number of cases without the persons affected, or present in the same room, noticing the peculiar smell of the product. The bromine element is generally considered responsible for the effects set up. At the same time certain authorities regard as possible a rapid fixation of the bromide on the lipoids which would facilitate diffusion of the poison in the nerve cells.

The product is a poison of the nervous system (especially of the central nervous system) showing itself in loss of consciousness, paralysing action on both sensation and motion — an effect which does not stop even on removal from the poisonous atmosphere, but, on the contrary, increases in intensity.

The great richness of the nervous tissues in lipoids may explain the special affinity of bromide of methyl for the nervous system and its special localization there.

In general, examination of the organs for the poison whether of human victims or experimentally in animals (even immediately after death) is negative. Examination, however, has been positive when intoxication has been massive and (experimentally) if the animal was rapidly killed. Predisposition is very variable and very important. Persons of lymphatic type show little resistance and nervous persons still less.

**CHANNELS OF ENTRY**

Respiratory tract and perhaps the mucous membranes. Irritation of the exposed mucous membranes occurs as a local effect.

**STATISTICS**

These are not numerous; cases, however, are said to be more numerous than the actual number reported would indicate. The first three cases — doubtful — were described in 1899 by Schueller (Switzerland) with 1 death; 2 in 1901 by Jaquet (although they occurred in 1898); 2 in 1910 by Bing (Switzerland); 1 by Zangger (attributed mostly to the impurities — methyl alcohol) (Switzerland); 1 case by Marmetschke, 1911; 1 in 1913 by Strassmann; 2 in 1915 by Floret; 1 in 1918 by Steiger; 9 in 1917-18 by Goldschmidt and Kuhn with 3 deaths; 1 by Röhrer in 1920 (fatal); and one other fatal by Löffler and Röttermann (also fatal), 1 case by Mazel and Jeanneret in 1921 (the reference is to a worker who had been slightly "gassed" four times); 2 fatal cases in 1917 in Switzerland; another case by Cade and Mazel, and 2 cases by the same authors in 1923 due to the inhalation of fumes (for some minutes) while bromide of methyl was being distilled — altogether a total of 27 reported cases in literature, of which 5 must be held to be doubtful.

In general, all the above cases are attributable to accidents in the work or explosions in the receptacles being fairly rare), or to the escape of gas due to leakage in the pipes or apparatus. The two cases which occurred in 1915 were caused by work with an ethereal solution of methyl bromide.

**PATHOLOGY**

The slight, moderate or severe forms all present generally characteristic nervous symptoms, almost always affecting the central nervous system, and more rarely the peripheral. The short incubation period, in the more or less serious and sometimes very slight accidents, between onset and development is said to be more apparent than real. This period, which is said by some writers to be unaccompanied by any effect on health and by others by a certain apathy and listlessness at work, lasts from one to two hours or even from 16 to 48 hours. This latent period is said to be longer the more severe the poisoning, and the period of onset and development is characterised by symptoms of moderate severity.

Slight attacks are much the more frequent; generally, workers in these cases are obliged to stand off for some days because of illness from time to time: vertigo, visual troubles, defects of movement, and general weakness.

Even among the persons most exposed to the injurious action of the gas, however, chronic poisoning has not been observed. Only repeated attacks of acute poisoning occur and usually they are not at all severe.

In very severe poisoning, after illness of short duration, the patient has epileptiform seizures, loss of consciousness, respiratory difficulty and death follows as a consequence of pulmonary oedema.

The intoxication has been summed up in its three stages thus:

(a) Prodromal or onset: after some hours (see above) sudden illness, visual affection, diplopia, dilated pupils, drunken gait, vertigo, more rarely syncope, excitement, headache, vomiting (rare), slow pulse, symptoms of progressive paralysis of the central nervous system. This stage may last from three to six days.

No bromine compounds have ever been discovered in the nervous system nor methemoglobin in the blood, though Steiger is reported to have found these. Bile pigments have some times been detected in the urine.
METHYL CHLORIDE — 240 —

(b) After a period of remission, which may often be absent, the second stage begins: pale skin, normal or subnormal temperature, movement and sensation affected, tremor, tonic and clonic spasms, somnolence, loss of consciousness, coma or delirium, or attacks of acute mania, epileptiform seizures, polyneuritis especially of the lower limbs, aphasia, diplopia, etc. This stage may last several weeks.

(c) Recovery: in the majority of cases may be prolonged for several weeks or even months before it is complete. For years afterwards there may be nervous affections (hypochoondria, neurasthenia, traumatic neurosis, insanity).

PROGNOSIS

Prognosis is favourable in most cases of a slight order. It is advisable to avoid prognosis except after the patient has been under observation for a few days.

PROPHYLAXIS

All necessary and effective measures must be taken to prevent explosion, breakage or leakage from the receptacles or pipes containing the product. These are in time corroded by the methyl bromide and frequently perforated. All precautions recommended in the case of volatile compounds should be taken: as, e.g., for petroleum essence, ether, etc. (See these articles.) Locally applied exhaust to remove the fumes and gas in all workplaces where they can escape from the receptacles; in the event of breakage or a leak the apparatus should immediately be closed and the distillation stopped; the workers exposed should put on box respirators which should always be at hand. The origin of the escape should then be carefully investigated and the needed repairs attended to. All the reported accidents have, in fact, been due to lack of attention or necessary precaution on the part of the workman. Oxygen should always be available.

LEGISLATION

Legislation is enacted only in so far as applies to hydrocarbons generally.

Compulsory notification: Netherlands, Switzerland. Notification might naturally be regarded as included in the wide formula adopted in certain states of the United States of America. Compensation is granted in Switzerland and in those countries which have scheduled, for purposes of compensation, injuries due to toxic gases and fumes or in which occupational diseases are compensated as such. (See "Occupational Diseases: Definition and Compensation").

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Methyl Chloride
(Monochloromethane)

French: Chlorure de Méthyle, Monochlorométhane. — German: Chlormethyl, Methylchlorid. Italian: Cloruro di Metile. — Spanish: Cloruro de Metilo.

CHEMICAL PROPERTIES

Methyl chloride (CH, Cl) is a colourless gas having a faint odour of ether and burning with a green flame. Its specific gravity is 0.952 (at 0° C.). It boils at 23.7° C. and its melting point is 103.6° C. It is slightly soluble in water, more soluble in alcohol and acetic acid.

PRODUCTION AND USES

It is obtained by the reaction of sulphuric acid and methyl alcohol on sodium chloride, or by the action of hydrochloric acid fumes with zinc chloride on methyl alcohol in an autoclave at about 100° C., or by treating trimethylamine derived from the evaporation residue of beet sugar molasses with hydrochloric acid and by distilling the hydrochloride at 300° C. There is then obtained a regular liberation of methyl chloride and of trimethylamine.

Methyl alcohol and other methylated amines are also given off. This latter method is chiefly followed in France. The distillation product is heated with hydrochloric acid and the methyl
chloride obtained therefrom is then purified, dried and compressed or put on the market in steel and brass cylinders with a resistance of 20 atmospheres and a capacity of 1.25 litres per kilogram of liquid. Methyl chloride is used in the chemical industry amongst other purposes for the preparation of chloroform, of tar colours, and in medicine as an anaesthetic. It is now increasingly used as a substitute for ammonia and sulphur dioxide in freezing apparatus.

Sources of Risk

In the above-mentioned processes, especially in the case of the manufacture of freezing apparatus, workers are exposed to the action of methyl chloride. During preparation of the product, however, the workers engaged in preparing it are also exposed to the action of methyl alcohol fumes, of the acids used, and even of the by-products liberated during the operation: nitrous gas, arsineulatid hydrogen, etc.

Toxic Action and Symptoms

Kobert states that methyl chloride has a toxicity as compared with that of chloroform of about one-quarter. Rambousek designates it as irritating and only slightly narcotic. Gerbis reported in 1914 two cases of poisoning affecting workers engaged in cleaning apparatus which had contained methyl chloride. The symptoms were as follows: in the first case slight facial paresis and extreme somnolence; the patient slept for twenty-four hours with three interruptions for meals and therapy. The patient in the second case complained earlier of frontal headache and sleepiness, and developed acute poisoning. He became very excited, ran about the factory and did everything in a wrong manner. On arrival at home he tore his clothes off, went to sleep and wakened next morning talking wildly. He then fell asleep again and slept for twenty-four hours. He said that after similar work he often experienced a sensation akin to drunkenness and could only recognise people quite close to him. He recovered after fourteen days.

Floret reports cases of long-continued delirium followed by cachexy and mental derangement. Diminution of vision is another symptom reported. O. Roth in 1923 reported two slight cases due probably to methyl chloride.

In 1926 F. Schwarz, Zurich, studied a case of poisoning affecting a worker engaged on the construction of a freezing apparatus, and undertook experimental research in relation thereto.

The most important contribution to literature on this subject, however, is that of H. M. Baker (1927), who had occasion to study 21 cases of indisposition and poisoning due to methyl chloride in an American factory making freezing machinery.

A worker in the factory had suffered from somnolence for which he blamed methyl chloride. He had to be shaken in order to get him to answer a question, could not take his meals, and had great difficulty in getting up in the morning. The enquiry revealed several cases of average severity amongst the workers in the factory, especially in the department for inspecting the apparatus, where the coils were filled with methyl chloride and compressed. During this operation chloride fumes penetrated into the workroom, for there was no exhaust device for ventilation. The gas was given off at the level of the worker's face; further, the gas being fairly heavy easily reached workers working near the ground.

The cases were less frequent in summer because all the doors and windows were open, but in the cold season, with no such outlets, the quantity of toxic fumes which contaminated the air was very high.

In order of frequency, the symptoms presented by the 21 patients were as follows: attacks of vertigo, drunken gait, feeling of lightness (the sensation of treading on air with the result that the worker lifts his foot higher than is necessary), somnolence to the point of interfering with work and taking of food, ptosis of the pupils, anorexia. Half of the victims were affected with nausea, loss of weight (1.5-4.5 kg.). Amongst 16 persons there was eye trouble, amounting in certain cases to diplopia (4 cases) due to temporary paralysis of the ciliary muscles; no lesion of the retina was found; dysphagia (3 cases).

When the symptoms diminished persistent insomnia (15 cases) set in, with trembling of the extremities (5 cases). In 18 cases the urine was alkaline. Examination of the blood was negative, similarly that of the cephalo-rachidian liquid in 5 severe cases.

Examination of the urine revealed the presence of formiates, the quantity of which corresponded with the severity of the poisoning. It diminished in proportion to attenuation of the symptoms. The evolution of the poisoning is very slow; in 7 cases recovery only took place after the lapse of from fourteen to twenty-one days.
Hygiene

All precautions should be taken to prevent liberation of toxic fumes in the atmosphere. Attention should be paid to ventilation, exhaust devices, etc. It is also advisable that all contact of the product with the skin and the mucous membrane should be avoided in view of the irritant and caustic action of methyl chloride on the skin.

Legislation

No special measures. Injuries due to methyl chloride are compensated in Switzerland.

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Methylenchloride


Methylenchloride, CH₂Cl₂, is got by action of chlorine or methane on chloride or iodide of methyl, or more frequently by reducing chloroform with zinc and hydrochloric acid. It is a colourless liquid smelling of chloroform and burning with a green flame; specific gravity 1.35, boiling point 40-41° C., slightly soluble in water, and easily soluble in alcohol, ether and other organic products. It changes on exposure to light and air, and in order to preserve it 0.5-1 per cent. of alcohol must be added. This product is highly poisonous.

Mica

French: Micas. — German: Glimmer. — Italian and Spanish: Mica.

The designation "mica" has been given by mineralogists to various double silicates of alumina and alkaline metals (potassium, soda) or other bases (magnesium, iron, lithia), characterised by a facility for scaling off into very thin, flexible flakes, more or less elastic and unbreakable. Amongst the numerous types of mica, only those which furnish large transparent sheets are used. Muscovite, or white potassic mica, is found in crystals which do not readily lend themselves to industrial uses; flogopite is a magnesium mica; lepidolite is a silicate of alumina, potassium, lithia and fluor; biotite is a black mica, etc.

The colourless grey, bluish, yellowish or brownish sheets may be divided into very fine leaves (of the thickness of fractions of a millimetre). Mica is not attacked by acids, remains long unaltered by the action of atmospheric conditions, is heat resistant, even at high temperatures, and is a bad conductor of electricity.

The most important deposits are situated in India, Canada and the United States. In Europe, the deposit already known and worked is that in the valley of Antrona (Domodossola) in Italy, situated at a height of about 1,400 metres.

Italian mica is found in the form of large sheets piled one upon another and occurring in a gangue constituted almost exclusively of quartz and white felspar. The work of extraction is trying, for the gangue is hard, and care must be taken to avoid damaging the sheets, the commercial value of which is in accordance with their size.

On the other hand, extraction is easier elsewhere, and there may even be used tools in the form of a knife. In Italy, the blocks are often detached by means of gunpowder, but the use of explosives is to be avoided, with a view to guarding the product from damage. The work of cutting, which is very slow, enables blocks of 1-1 cubic metre, weighing 1,300-1,500 kg., to be obtained. The first sorting leads to the selection of sheets fit for utilisation; the remainder is cut into small blocks of 10-50 kg. Extraction is effected by experts, who obtain the sheets (the thickness of which is only a few millimetres) by means of wooden hammers and small scalpels with a very large blade. After sorting the blocks and the sheets, these are reduced to thin, supple layers, polished and classified in accordance with their dimensions, their colour, transparency, etc. The remainder is ground mechanically in order to extract the smaller fragments, which are used in the preparation of mica dust.

Mica is used principally as a substitute for glass, in cases where the latter would not be heat-resistant: windows, lamp shades, lamp glass, windows and doors in stoves; in the electrical industry for insulating purposes, for various furnishings and
parts of dynamos, motors, and electric apparatus and storage batteries. The smaller pieces serve as ornaments in the ironmongery trade for making fancy goods, safety eye-glasses, etc. The debris and mica dust are used in the pottery industry to give a gloss to certain kinds of pottery, in the manufacture of certain decorative papers, imparting to these a flaked effect, in the manufacture of luminous signs and postcards. In the chemical industry mica forms an ingredient of certain varnishes, enamels, special lubricants, and certain explosives. It is further used in the manufacture of paper and cloth employed for insulating purposes, and as wrappings (mica paper, mica cloth), etc. Finally, mica is used in the preparation of micanite, which is a substitute for mica as regards colour and transparency, and which is a substance offering the greatest resistance to electric currents. It is used for the manufacture of insulating plates for storage batteries.

Micanite is obtained by submitting to very high pressure thin sheets of mica attached to each other by small quantities of insulating cement and varnish. There are on the market, moreover, other similar secondary products.

The risks presented by the manipulation of mica are connected with the dust produced, which exercises an irritant mechanical action on the skin, the eyes, and the respiratory passages. Prosser White refers to cases of eczematous and ulcerative lesions occurring among workers making micanite, due either to mica dust or to the use of denatured alcohol and solvents (turpentine), colophane, etc.

Bialokos, of the Institute for Occupational Diseases at Leningrad, has examined 26 workers (24 of whom were women) engaged in the manipulation of mica. Their ages ranged from twenty to thirty, and the average duration of work was 7.4 years.

In conformity with the system followed in the Institute in the case of examination of small groups of workers, Bialokos effected simultaneously an investigation into conditions amongst workers making cardboard, with a view to acquiring a basis of comparison, the latter group offering analogies in regard to age and certain working conditions with the mica workers. The examination has revealed a high percentage for loss of hair (16 out of 24), which in the case of the workers making cardboard was only noted as affecting 5 workers.

Affections of the upper respiratory passages only occurred in 6 cases, and 3 women workers were found to be suffering from asthma. The figures for the female workers in the cardboard industry were respectively 13 and 9.

A similar investigation was carried out by Kogan-Jasny amongst 52 male workers, and revealed the fact that 78 per cent. suffered from sub-cutaneous troubles, which Bialokos, despite the most careful examination, had not observed. These sub-cutaneous formations, resembling glands, took the form of a necklace and were revealed on anatomo-pathological examination to consist of a fatty substance. Hence arose the designation "Oleoma silicatum". In the urine 0.08 per litre of bi-oxyde of silicon was found.

Kogan-Jasny's enquiry covered women workers in an electric apparatus factory who used micanite containing 40 per cent. of dixoide of silicon for the manufacture of insulators. 52 women and 2 men had worked with the micanite for five years and complained of fatigue, headache and vertigo; 38 suffered from loss of hair; 31 from a sensation of dryness in the mouth; 36 from coughing and dyspnoea and 28 from necrosis of the alimentary organs. Dust in the workroom was very abundant and the workers were covered with it. Medical examination revealed in 26 cases sclerosis of the apex of the lungs (13 of a specific type) and in 19 cases heart disease. All suffered from anaemia, which was serious in 8 cases. Digestive derangements were reported in the case of 23 workers and nervous troubles in the case of 34.

Kogan-Jasny believes that micanite traverses the skin to the sub-cutaneous tissue, where it causes necrosis. It also enters the respiratory and digestive passages, which it impregnates, giving rise to the general disease form designated by the author "silicosis universalis".

The hygiene measures to be adopted are of a general order: an anti-dust campaign against the effects of the toxic products employed in the course of the processes, either by generalised or localised systems of ventilation.

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Miners' (Coal Miners') Diseases


The underground seams of coal are buried in rock and are reached by means of vertical shafts and horizontal galleries which start from the shafts and are carefully lined with brickwork or timber to resist the pressure. Passages protected in the same manner connect the galleries with the coal face, where the actual getting of coal is carried out.

Hewing by hand is carried out by means of picks (when the ground is loose), mattocks, pointed bars, and wedges. At the present time these tools are often replaced by machinery driven by compressed air or electricity.

Drilling and mine work by which large masses of coal and rock can be got at the seams are only possible in mines which are not affected with fire damp. This applies also to the extraction of hard coal in thin seams. The explosives used consist of mine powder, dynamite or other explosive; they are fired either by a fuse or electricity. Explosions produced by liquid air are also very often used at present. A first rough sorting of the coal from the useless material takes place in the mine itself. In narrow seams the coal is first carried by hand by means of baskets (hoppers), then mechanically in metal conveyers, from which it falls into barrows which a workman pushes as far as a haulage road, where it is loaded into tubs drawn on rails by ponies.

On certain British coalfields coal from thin seams is loaded at the face on to small sledges, known as hods or putts, which are dragged by youths to branch roads where the contents of the sledges are transferred to tubs. The tubs are worked by hand on rails into the haulage roads where ponies draw them to the pit shaft. In thick seams the galleries are sufficiently large for the tubs to be drawn either by locomotives or by electric traction, or by cables or chains worked by a fixed motor situated either in the mine itself or outside. Often also the full tubs descend by an inclined plane (dillies).

Part of the shaft or a special shaft is reserved for bringing up to the surface the tubs of coal. In another part, or in as a third, called the cage, the cage, hung on a steel rope, which lowers the workmen to the bottom of the shaft or brings them up to the surface again. In Great Britain the same cage is used at certain times for coal tubs, at another for men.

In certain countries (Germany, for example) each mine must have two separate and independent exits having access to all parts of the mine.

At the surface there is a fresh and more careful sorting of the coal from such useless material as rocks and slaty coal. This is carried out either by washing or by screening.

The getting of coal takes place at different depths. As the seams are generally superimposed, the upper seam is worked first to establish the ventilating gallery. It is there that big ventilating fans are placed which blow fresh air into the mine and draw out vitiated air. Air is brought into transverse galleries by long tin ducts and directed to the various points where men are working, whilst a special apparatus draws out vitiated air. This aeration serves to dilute the dangerous gases in the circulating air (see further on) and also to temper the heat which steadily increases as one descends.

In mines not affected with fire damp, lighting is effected by naked candles, oil or acetylene lamps with naked flames, but now the galleries are often lighted by electricity. In mines affected with fire damp, safety lamps are used; these are fed with oil or spirit; the side air inlet and outlet holes of these are made of gauze of fine metal wire which always remains cool and so prevents the combustion of dangerous gas mixtures. Further, this lamp has the advantage of showing the peculiar appearance of the flame. (See article "Mines (Hygiene in").

Dangers

Stassen summarises as follows the causes of injury to health encountered in mining: (1) lack of sunlight; (2) deficiency in oxygen as a consequence of inadequate ventilation; (3) close atmosphere; (4) toxic atmosphere; (5) repeated chills due to sudden passage from hot working posts to relatively cold galleries in the absence of all precautions; (6) inhalation of dust.

The gases which may vitiate the air of the workings are fairly numerous.

Carbon monoxide (CO) causes death, and often fatal poisoning, especially after an explosion of mine gas or of coal dust. These poisonings are characterised not only by general symptoms of poisoning, but also by burns due to explosion or fire. It is to be noted that carbon monoxide is very often inodorous. The Bureau of Mines of the United States Department of the Interior reports a case where 0.20 to 0.30 per cent, of carbon monoxide sufficed to kill a canary, whilst persons who were present did not show any symptoms. But a strength of 0.6 mg. per litre of air has injurious effects. High temperature and great humidity also favour the absorption of carbon monoxide.

Methane (CH₄) is the principal constituent of fire damp, or the gas found in mines. Mixed with air and carbon monoxide it forms a formidable explosive combination. It is known that methane is set free especially in places
where there is decomposition of thick coal either by slow accumulation or by sudden massive release from pockets. It is sufficient for there to be 5 to 15 per cent. of this mixture in the air to give rise to danger of explosion. Safety lamps show a strength of 2 per cent.

The effects of explosions caused by naked lamps or by the firing of explosives are rendered more serious because naked lamps or by the firing of explosives are rendered more serious because coal dust which is found throughout mines is raised in the air by the fire damp explosion; it is then ignited and explodes in its turn.

Ethane (C₂H₆) and ethylene (C₂H₄) may also, though this is rare in normal conditions, vitiate the air of mines. They are found more readily after explosions or fires. In certain mines of New South Wales, Atkinson (1923) reported the presence of a mixture of various gases (carbon dioxide, carbon monoxide, methane, nitrogen, and hydrogen) which he calls bottom gas; it settles in the form of a sheet upon the ground, like a liquid. This heavy gas is however rapidly dispersed by ventilation currents.

The gases from combustion of fire damp consist of carbon dioxide (4.7 per cent.), carbon monoxide (0.5 to 1.5 per cent.), nitrogen (80 to 85 per cent.), oxygen (12 to 17 per cent.). The quantity of carbon monoxide is higher after an explosion when there is not sufficient oxygen at the site of the accident for complete combustion of the gaseous mixture. Theoretically the combustion of methane and air should not give rise, according to Lewin, to carbon monoxide which appears — as of course one understands — when coal dust is involved in the explosion. Hence in explosions in mines this gas is always present (from 0.01 to 1.5 per cent.).

The forms of delirium and the psychic disturbances that are met with in cases due to above causes are generally of short duration; they may nevertheless be repeated at short intervals.

Carbon dioxide (CO₂) in sufficient quantity exerts a harmful physiological action upon the system. Its presence is due not only to the air expired by the living creatures (men, animals), who live in the mine, but also to chemical changes which take place in the materials found in the ground and in the galleries.

While Hill reported in 1920 that a strength of three parts of CO₂ in 100 parts of air increases pulmonary ventilation by 100 per cent., that a strength of 5 per cent. increases it by 300 per cent., and that a strength of 10 per cent. cannot be borne more than one minute because it causes headache, sweating, troubles of vision and tremors, the U.S. Bureau of Mines (1923) is of opinion that the same percentages of CO₂ in oxygen is better tolerated and that a percentage of 7.2 parts of CO₂ in oxygen gives only an increase of 200 per cent. of the pulmonary ventilation, and that a percentage of from 9 to 10 only caused the above-mentioned troubles after ten minutes' inhalation.

While an increase of carbon dioxide in the surrounding air causes the symptoms described above, a reduction in the amount of oxygen causes vertigo and tachycardia, etc., as well.

Occasionally some pockets of sulphur-etched hydrogen may vitiate the air in the galleries. The miners easily recognise the presence of this gas, which may also be set free by the firing of explosives, by its smell resembling rotten eggs. When sulphur-etched hydrogen is mixed with seven times its volume of air, it forms a violently explosive mixture.

Nitrous gas may also be found with carbon monoxide in the air of mines after the use of such explosives as dynamite or roburite. The clinical picture noted amongst workers in tunnels in Italy (Taramelli, 1931) has been attributed to this mixture of gases. It consists in loss of consciousness, cutaneous anaesthesia, abolition of superficial and deep reflexes, phenomena of vasodilatation followed by peripheral vasconstriction, headache, etc.

Among the infections which may attack miners the most important certainly is ankylostomiasis (see that article). The first case reported in the German mines from the district of Dortmund dates from 1885; the infection spread to the district of Bonn and developed to such an extent that in 1902 there were 1,555 cases. Medical examination of all the underground workers showed 17,161 carriers of worms. At the commencement of 1909 the frequency of cases of ankylostomiasis had diminished by 95 per cent., and recently by 99.3 per cent., due to the energetic measures of prophylaxis adopted, including microscopical examination of faeces, isolation of infected miners, exclusion of infected miners from underground work, sterilisation of faeces containing eggs, and rapid removal of the excreta buckets.

Prophylactic measures, on the one hand, and conditions of habitat unfavourable for the eggs, on the other, easily explain the good healthy condition of certain districts.
According to the Belgian press, an epidemic of ankylostomiasis and amoebic dysentery (which is, however, disputed) was introduced (1924) into certain mining districts by labourers from China, Annam, and North Africa. Thirty cases, 7 of which were fatal, have been recorded on the Nord coal-fields in France.

This infection has also been reported in certain mines of Arizona (U.S.A.), in the Belgian mines in 1920-1921 some cases of infection by 

The symptoms are those of acute inflammation of the skin and of subcutaneous tissue: heat, redness, swelling, and pain. At first the skin is unbroken, but pits easily. Generally suppuration occurs with or without involvement of the adjoining bursae or tendon sheaths. In the case of the knee and elbow, the course of the disease is usually benign and without sequelae; in six weeks, or even less, recovery of functions may be expected. In the case of the hand, on the contrary, the infection may involve the tendon sheaths and cause very serious maiming as a sequela. Some fatal cases have been reported, due generally to septicemia; one case of the knee and one of the elbow; no fatal case is known for the hand, but it is probable some have occurred.

These conditions are very important on account of the very heavy legal compensation imposed upon employers, and also on account of the suffering and incapacity for work which they cause.

With regard to frequency the lesion of the knee has for some years taken second place, coming next after miners’ nystagmus, in the list of compensated diseases, and that of the hand the third place. Lesions of the elbow and synovitis of the wrist are certainly less frequent than the foregoing, but still are as numerous as cases of lead poisoning and more so than industrial anthrax.

It is to be remarked that the conditions are not diminishing, which
shows that preventive measures have not been taken or are without result.

The total of all cases compensated under the British law were as follows:

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<tr>
<td>Of the knee</td>
<td>2,740</td>
<td>2,502</td>
<td>2,379</td>
<td>2,197</td>
<td>2,644</td>
<td>3,406</td>
</tr>
<tr>
<td>Of the hand</td>
<td>1,000</td>
<td>1,122</td>
<td>1,102</td>
<td>0,333</td>
<td>1,349</td>
<td>1,705</td>
</tr>
<tr>
<td>Of the elbow</td>
<td>308</td>
<td>299</td>
<td>292</td>
<td>335</td>
<td>392</td>
<td>438</td>
</tr>
<tr>
<td>Synovitis of the wrist</td>
<td>102</td>
<td>179</td>
<td>148</td>
<td>217</td>
<td>227</td>
<td>316</td>
</tr>
</tbody>
</table>

From the point of view of compensation, it is also interesting to note the number of cases which are receiving compensation continued from the preceding year: in 1919 there were 144 cases; in 1920, 125 cases; in 1921, 135 cases; in 1922, 185 cases; in 1924, 294 cases; in 1925, 240; in 1926, 290; in 1927, 427; in 1928, 318; and in 1929, 357.

Comparison with nystagmus is here of interest; in 1921 there were 1,913 new cases and 4,054 continued cases. The much smaller proportion of continued cases of cellulitis indicates the much more rapid restoration of working capacity.

The new cases reported per thousand persons employed underground were as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of underground workers</th>
<th>Cellulitis</th>
<th>Synovitis of wrist</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hand</td>
<td>Knee</td>
<td>Elbow</td>
</tr>
<tr>
<td>1910</td>
<td>855,485</td>
<td>0.93</td>
<td>1.34</td>
</tr>
<tr>
<td>1911</td>
<td>895,485</td>
<td>1.10</td>
<td>1.41</td>
</tr>
<tr>
<td>1912</td>
<td>1,031</td>
<td>1.07</td>
<td>1.93</td>
</tr>
<tr>
<td>1913</td>
<td>932,094</td>
<td>0.79</td>
<td>1.34</td>
</tr>
<tr>
<td>1914</td>
<td>908,133</td>
<td>1.14</td>
<td>1.37</td>
</tr>
<tr>
<td>1915</td>
<td>974,099</td>
<td>0.85</td>
<td>0.97</td>
</tr>
</tbody>
</table>

In Belgium, according to Stassen, among 30,000 workmen (of whom about 27,000 were employed underground) there were on an average 50 to 60 cases of cellulitis and bursitis of the knee, 40 cases of cellulitis and bursitis of the elbow, and 25 cases of cellulitis of the hand. The proportion per 1,000 persons employed is given as 2.04 for the knee, 0.92 for the hand, and 1.11 for the elbow, figures which are higher than those for Great Britain where for all mines the figures are: 1.19 for the knee, 0.87 for the hand, and 0.13 for the elbow.

The dusty work, assisted by humid heat and continuous friction causes an intertrigo upon the external part of the forearm and the internal part of the thigh. The scars are almost always of a blue-black colour, for the miners have a habit of touching all the lesions of the skin with their hands soiled with coal dust.

Upon any part of the body one may observe a form of eczema (water itch) which resembles smallpox and is situated on the hands, face, neck, limbs, and feet.

This condition is caused by dirty water which runs down from the roof and sides of the mine. In America there was in 1912 a real epidemic which Whishart attributed to sulphur dioxide and sulphuretted hydrogen dissolved in the water. The condition has often been confounded with true itch. Some eczematous conditions, often very serious, situated especially on the arms and limbs, are due to the larva of ankylostomiasis (see that article).

A dermatitis reported by Mackenzie (1898) was due to handling wood treated with creosote, which also caused quite serious conjunctivitis.

Amongst the miners of Morro-Velho, New Lima, Brazil, forms of dermatitis due to arsenical compounds contained in the ores worked have been noted, as well as attacks of urticaria from handling of certain woods for making pit props (Schinus terebinthifolius, Astronium commum, Bowdichia nitida, etc.).

The skin affections noticed by Cave-naille among the underground men at the colliery of North Fléni at Ghlin-Mons, are arranged as follows in order of frequency: boils, due to lack of cleanliness and profuse sweating, which among certain men appear after three to four weeks underground, whilst other miners remain immune for years and then show suddenly a crop of boils without apparent cause; sudamina; intertrigo, chiefly between the fingers; prurigo; and pimples, due to the peculiarly irritating action of the underground water or ground.

Massar (of Rocour) has also drawn attention to the blind boil of miners which is favoured by the general bad state of health of the individual, over-worked, badly nourished, and dirty. It is situated by preference on the anterior surface of the limb, below the
prepatellar bursa, but is found also on
the external border of the forearm, below the elbow, and sometimes at the
wrist, that is to say, always on parts
exposed to blows more or less violent.
The prognosis is as a rule good; the
blind boil healing in some days. It is
generally single and there is no infec-
tion of the surrounding part. The
treatment is very simple and of a sur-
gical nature.
Coal dust which settles upon the skin
blocks the sudoriferous glands and also
causes furunculosis. If the dust is
deposited in the auditory meatus it
causes eventually an eczematous
eruption.

Resulting from the had habit which
miners and workmen have of wiping
their hands with the back of the
hand, Fabry has reported among 255
miners, in a period of twenty years,
a form of cutaneous tuberculosis
situated on the back of the hands and
fingers. It had been caused by inocu-
lization from tuberculous expectoration
on the upper part of the skin; the thin
skin of the hands. However, recent
observations (1929) point to the conclu-
sion that such cases are becoming rarer.
The reduction is said to be attributed
to improved hygienic conditions and
the more expansive applications of
mechanical apparatus in the mines
(Fabry).
The prolonged stay in places where
daylight does not penetrate causes a
loss of colour from the skin and a
certain degree of anaemia which is
also favoured by vitiated, stagnant air,
excessive heat, a high degree of humi-
dity and perhaps by the poisonous
action of certain explosives (case of
Ebright, 1914).

Nevertheless the blood formula is, as
a rule, normal. The work of the miner
is especially injurious when it
is carried out in low galleries, at great
depth, where the temperature is high.
A miner employed in a very narrow
space must work with his pick, or
drill shot holes, in a crouched position,
or even lying down, as well as having
to shift, at the cost of great muscular
efforts, the extracted coal through
narrow passages over rough ground.

Freise (1930) has reported the occur-
rence amongst deep-level miners in
Brazil of troubles similar to those
affecting caisson workers: singing in
the ears, accelerated and then retarded
respiration, troubles which disappear
after one to two hours at work, but
which in a case of undernourished
individuals, leave sensations of pain in
the limbs. Where workers remain for
long (several weeks) at work under the
above conditions they become subject
to nutritional derangement, loss of
weight, anaemia, etc.

Mr. Moss calculated the energy used
by English miners by measuring the
consumption of oxygen and muscular
force.

According to his researches the air
inspired in one minute for loaders of
slack with hand shovels and rakes
is 36.2 litres; for hewers of solid coal
working with picks, 35.3 litres; whereas
at rest the consumption fell to 16.3 litres.

Average figures for muscular force
of the body, expressed in ft. lb./min.,
are given for loaders of slack as 4,000,
for hewers of coal in the floor, 2,500;
and for cutting and erecting timber,
3,000.

These figures show at once which
are the groups of workers most
exposed to fatigue and its consequences.

The effort thrown on the respiratory
apparatus necessitates breathing deeper
and more often and predisposes to the
loss of plasticity of the lung tissue.
The inhalation of coal and mineral
dust prepares the ground for and
favours the development of this lesion,
which develops at first at the lower
parts of the respiratory apparatus and
may next become general and attack
the upper parts, when the workman is
obliged to make forced expirations
after closing the glottis (especially
efforts in attacks of coughing). The
inhalation of vitiated air, the fatigue
occasioned by mounting ladders or
stairs to leave the mine, etc., are
factors which play a certain part in
the causation of emphysema and the
fatigue of the respiratory apparatus.

Nevertheless it may be said, even in
the absence of precise statistical facts,
that the frequency of pulmonary
emphysema has diminished among
miners, for their occupation, which is
becoming more and more mechanical,
calls much less for working in
awkward and painful positions.
Besides, advance in the technique of
ventilation and the suppression of dust
has contributed to diminish the fre-
quency of respiratory diseases.

The measures to be taken against
dust in mines during drilling operations
and hewing are dealt with in the
article "Mines (Hygiene in)".

The physical and chemical properties
of dust found in the air of the galleries
determine the pathological conditions
of the respiratory apparatus of miners.

But even with the best arrangements
it is clearly impossible for the worker
to avoid all exposure to dust. The
miner is certain to inhale during
work quite a large amount of dust;
hence anthracosis is still looked upon
as an industrial disease among miners. (See articles "Dusts, Fumes and Smoke" and "Tuberculosis — Silicosis").

In 1815 in England Pearson submitted a report to the Royal Society on the presence of coal in the lungs of miners. This matter was taken up later by Gregory and Christesin (1831). These three experts also drew attention to the frequency of tuberculosis among miners. Laennec attributed the expectoration. In part, however, they attain even the furthest ramifications of the respiratory tree.

If the miner is attacked, as is often the case, with acute or chronic catarrh of the respiratory passages, the mucous membrane comes no longer to possess the defence of the vibratile cilia, and the dust then is deposited in the tissue which becomes of a black colour. The abuse of alcoholic drinks weakens or arrests this defensive action of the cilia,

black colour of the lungs to the smoke of lamps; but Behier in 1837, and Billier in 1838, attributed the condition to particles of coal. Further, in 1827 Gobert of Hainault, and Kuborn, of Liège, recognised miners' asthma with its characteristic black expectoration.

Particles of coal which are inhaled are partly retained in the upper respiratory passages, and are evacuated either when blowing the nose or with which leaves the way open for dust. The miner is obliged, after many years of hard work in an atmosphere charged with dust, to breathe more and more deeply, strongly and rapidly. The dust, having reached as far as the furthest ramifications of the respiratory tree (alveoli), passes through the walls of the alveoli into the interstitial tissue where it is found in large quantity in the vicinity of the blood
vessels. Whilst a portion is confined to this area and causes cellular proliferation, leading to the formation of young connective tissue which contracts, another portion is carried into the lymphatic vessels and passes to be deposited all around the hilum of the lungs and penetrates into the peribronchial connective tissue and more especially into the multiple glands of the hilum and into the bronchial glands.

In anthracosis of old standing it is found that the lungs show on their exterior and on section a more or less blackish appearance in proportion to the quantity of coal dust in the tissues, and similarly have a consistence more or less hard.

A good description of anthracosis, or anthracotic pulmonary fibrosis, has been given by Courtois (1930), who refers to areas of sclerosis accompanied by compensatory areas of emphysema and to the following radiological symptoms: nodular opacities and by compensatory areas of emphysema refers to areas of sclerosis accompanied by marked emphysema or less hard.

...the more irritating the dust, that is to say, the more sharp particles it contains, resulting from hewing coal and crushing rocks, etc., the more numerous are the lesions of the pulmonary tissue. In the latter case the lungs are very black and have the appearance of leather; they contain little air and show in places points of calcification. These cicatricial modifications cause dilatations of the bronchial tubes. According to Patschkowski (1924), anthracosis among miners of the Rhine district and Westphalia allows only very guarded prognosis when it is associated with tuberculosis and chalicosis.

In slight cases of anthracosis where the objective and subjective symptoms are slow to appear, the capacity for work by the miner is not diminished.

This disease shows itself generally after a period of work of ten years, rarely before, more frequently among the hewers than among other underground workers. Workmen employed in drilling rocks which are found with the coal seams are more often affected than the coal hewers.

Boehme, who has studied (1925) pneumoconiosis in miners of the Ruhr district, insists particularly upon the difficulty of diagnosis—which may nevertheless be facilitated by radiological examination, even when the lesions of the respiratory apparatus have not caused subjective troubles in the miner. Out of 1,500 workmen examined, he found that the hewers and drillers were the most frequently affected. As among these 1,500 workmen young men were the most numerous, he was only able to find 81 cases of pulmonary fibrosis from inhalation of dust, of which half were incapable of work.

Radiological examination of 71 coal hewers who had worked more than ten years showed, in 23 cases (32 per cent.), a fibrosis of a slight degree and pneumoconiosis only in three cases (4 per cent.).

Among 49 stone cutters with more than ten years' work he found by radiological examination 33 cases (67 per cent.) of fibrosis, of which 29 (that is to say, 59 per cent.) were fairly serious.

It certainly is not possible to draw general conclusions, but it may be said that these two classes of miners are the most seriously affected by pneumoconiosis.

Post-mortem examination of 16 serious cases has shown in the lungs 27 per cent. of dry residue, 4.2 per cent. of ash, 5.4 of coal, and 2.3 of silica, whilst the normal lung contains an average 17 per cent. of dry residue, 0.7 of ash, and traces of smoke and silica. Pneumoconiosis existed when the lung tissue contained 2 per cent. of ash, 0.7 and upwards of silica, 1.6 and upwards of coal.

An autopsy on 240 miners from the Ruhr, who had been exposed to dust, enabled Hustedt (1931) to observe 177 cases of definite silicosis of nodular type and 35 cases without nodular formation. The majority of the deceased workers ranged in age from fifty to fifty-five years though 30 were over fifty-five. A very serious case was that of a worker aged thirty-seven. Of the 173 serious cases, 120 had at the same time active tuberculosis. Death occurred in 76 per cent. of the serious cases as a result of cardiac failure; in 9 of pulmonary tuberculosis, and in 14 of pneumonia. The duration of working experience had been from three to thirty-five years in cases of serious types of disease; very short (three to four years) for forms of silicosis and tuberculosis. On an average the working life of the miners was found to be between twenty-two and twenty-five years. An effort to determine how long a worker attacked by a serious
form of silicosis may live after appearance of grave symptoms (dysphoea cardiac insufficiency) gave the following results: of 170 cases, 9 died before reaching the delay requisite for compensation, 31 during the first year; only 35 were still living at the end of four years, and 3 at the end of six years.

Legislation in Western Australia provides for detection of cases of pulmonary tuberculosis, the granting of compensation to victims, and isolation of those affected. The first medical examination instituted (1925-1926) showed 3,257 out of 4,067 miners (80.1 per cent.) to be free from respiratory disease of occupational origin. Of those affected by this disease, 655 (16.1 per cent.) suffered simply from silicosis in an early or advanced stage; 143 (3.5 per cent.) from silicosis with tuberculosis, and 12 (0.3 per cent.) from tuberculosis without silicosis. The workers belonging to the last two groups were removed from the industry. Of the 3,912, 1,131 (28.7 per cent.) suffered from silicosis with tuberculosis and 3 (0.07 per cent.) pulmonary tuberculosis. Of 451 miners suffering from silicosis in 1926, 86 (17.5 per cent.) had now developed tuberculosis complications.

In Tasmania the medical examination covered 60 per cent. of the miners; amongst 455 engaged at the bottom of the mine 27 (5.9 per cent.) suffered from simple silicosis; 14 (3.1 per cent.) from silicosis with tuberculosis; and 5 (1.1 per cent.) tuberculosis. In another mine, amongst the workers who had worked from eleven to fifteen years, 22 (2 per cent.) suffered from silicosis.

Seltmann reported, in 1866, concerning inflammation of the lungs among miners—a disease fairly common in England and rare in Germany—the formation of cavities and necrotic changes of certain parts of the lungs, without any participation of the tubercle bacillus. The condition is found today very rarely among German miners, but is, on the other hand, now generally attributed to infections and chiefly to tuberculosis. A remarkable frequency of bronchitis and asthma, very probably connected with the amount of silica in the rocks which are found with the coal, has been noted especially in Great Britain (Lancashire). Fifty years ago asthma was very common among miners, but hygienic measures, chiefly improved ventilation, have ameliorated the conditions of work in the mines and reduced in a remarkable manner this special form of sickness.

Courtois has likewise drawn attention to cases of anthracotic fibrosis complicated with tuberculosis occurring specially amongst coalminers between forty and sixty years of age and following a typical clinical evolution: the tuberculosis usually of a serious type commencing generally with a form of caseous pneumonia.

The death rate from bronchitis and pneumonia is important; in Great Britain, for example, they exceed the average on certain coalfields, but not on all. Deaths from pneumonia are sometimes partly a sequel of carbon monoxide poisoning, and partly due to affections of the heart, the blood vessels, and the respiratory passages.

Pneumonia is also frequent among miners in the United States and in certain districts of South Africa, who are often exposed to the action of nitrous fumes with their capacity to set up pulmonary complications.

These serious cases and very serious pulmonary affections among miners are not as frequent as formerly, and this is due in part to good medical supervision of the working classes.

The sickness and death rate of miners from tuberculosis has always been lower than that of other trades. As a matter of fact, in the English statistics they are almost at the head of the list of occupations least affected by tuberculosis. According to statistics of deaths for 1890-1892, 1900-1902, and 1910-1912, for all forms of tuberculosis, miners come immediately after the agricultural class.

The death rate of miners from tuberculosis—according to Collis—was 1, whilst for all other males, aged 15 years and upwards, in England and Wales it was 2.1.

Certain English experts are of opinion that inhaled coal dust exercises an antiseptic action on the tubercle bacillus, and Haldane has even found that animals exposed to the inhalation of coal dust and then placed in the open air, did not show any particles of coal in the alveoli of the lungs. On the other hand, when these animals were exposed to silica dust, it was found that the particles became fixed upon the alveolar epithelium and are removed very slowly by the phagocytes. It will be interesting, therefore, to study what are the substances contained in coal which excite phagocytosis. It is to the variety of the rocks which accompany the seams of coal in the different English mining districts that must be attributed the various degrees
of reported sickness and death rates from tuberculosis. Statistics for 1910-1912 give the following comparative figures:

<table>
<thead>
<tr>
<th>Mining district</th>
<th>Comparative mortality, ages 25-64</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All causes</td>
</tr>
<tr>
<td>Nottingham</td>
<td>570</td>
</tr>
<tr>
<td>Derbyshire</td>
<td>531</td>
</tr>
<tr>
<td>Durham and Northumberland</td>
<td>635</td>
</tr>
<tr>
<td>Staffordshire</td>
<td>717</td>
</tr>
<tr>
<td>Yorkshire</td>
<td>758</td>
</tr>
<tr>
<td>South Wales and Monmouth</td>
<td>777</td>
</tr>
<tr>
<td>Lancashire</td>
<td>941</td>
</tr>
</tbody>
</table>

It is not necessary to insist on the influence of other factors which regulate the frequency of tuberculosis (see that article). But attention must be specifically directed to the factor of housing, for the conditions of life of the miners are very different from those of most other workers. The miners live in isolated villages or in valleys where it is usually difficult to build a good house. The son almost always follows the father at the colliery and hereditary influence certainly plays an important part in his life. The strenuous work, the cramped position while at work, the surrounding temperature, and the air currents are factors which must be taken into account.

Research effected by Allen (1929) in regard to reaction to tuberculosis amongst native workers occupied in a South African mine, showed rapid increase in positive reaction during the first six months at work. These reactions continued for a period somewhat beyond one year, but fell below the average at the end of a period of about ten years.

In Germany a recent enquiry into the frequency of diseases and especially of tuberculosis among miners in the district of the Ruhr has given the following very interesting results:

### DEATH RATE AMONG THE MEMBERS OF THE MINERS’ TRADE ASSOCIATION OF BOCHUM

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of members (average)</th>
<th>Tuberculosis (corrected figures)</th>
<th>Pneumonia</th>
<th>Bronchitis</th>
<th>Influenza</th>
<th>Other causes</th>
<th>All causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910</td>
<td>351,188</td>
<td>7.86</td>
<td>7.4</td>
<td>1.9</td>
<td>0.3</td>
<td>49.3</td>
<td>59.7</td>
</tr>
<tr>
<td>1914</td>
<td>388,385</td>
<td>6.5</td>
<td>7.8</td>
<td>2.4</td>
<td>0.1</td>
<td>40.2</td>
<td>66.7</td>
</tr>
<tr>
<td>1916</td>
<td>397,508</td>
<td>6.1</td>
<td>7.8</td>
<td>2.4</td>
<td>0.1</td>
<td>40.2</td>
<td>63.2</td>
</tr>
<tr>
<td>1918</td>
<td>365,300</td>
<td>10.9</td>
<td>41.6</td>
<td>5.3</td>
<td>7.7</td>
<td>74.0</td>
<td>150.3</td>
</tr>
<tr>
<td>1920</td>
<td>405,419</td>
<td>10.0</td>
<td>11.9</td>
<td>3.0</td>
<td>8.3</td>
<td>54.8</td>
<td>83.3</td>
</tr>
<tr>
<td>1921</td>
<td>546,415</td>
<td>10.8</td>
<td>7.9</td>
<td>1.3</td>
<td>2.0</td>
<td>46.9</td>
<td>63.8</td>
</tr>
</tbody>
</table>

During the war the death rate from tuberculosis was three times greater than that before the war.

Grouped according to age and with 10,000 members in each group the death rate from (a) all causes and (b) tuberculosis was as follows:

<table>
<thead>
<tr>
<th>Age group</th>
<th>1910 (a)</th>
<th>1910 (b)</th>
<th>1920 (a)</th>
<th>1920 (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 20 years</td>
<td>70.2</td>
<td>13.9</td>
<td>48.8</td>
<td>10.6</td>
</tr>
<tr>
<td>20-40</td>
<td>74.0</td>
<td>11.1</td>
<td>54.5</td>
<td>13.7</td>
</tr>
<tr>
<td>40-50</td>
<td>63.0</td>
<td>2.9</td>
<td>49.5</td>
<td>7.4</td>
</tr>
<tr>
<td>50-60</td>
<td>100.5</td>
<td>9.0</td>
<td>94.8</td>
<td>10.9</td>
</tr>
<tr>
<td>Above 60</td>
<td>166.3</td>
<td>10.2</td>
<td>154.4</td>
<td>10.0</td>
</tr>
<tr>
<td>Totals</td>
<td>83.5</td>
<td>10.0</td>
<td>68.3</td>
<td>10.8</td>
</tr>
</tbody>
</table>

This enquiry has brought out the fact that the death rate from tuberculosis among miners of the Ruhr district was lower than that of all other trades, and likewise of the dusty trades. According to Bochime tuberculosis among those affected with pneumoconiosis usually follows a very slow development, rapid development being very rare. Among 81 miners with fibrosis of the lungs he found only 15 (19 per cent.) with serious tuberculosis; and of these 13 were stone cutters and only two coal hewers.

The very small amount of tuberculosis among miners can perhaps be explained in the following ways: only robust men adopt the occupation of miner, for they know that the work is very strenuous. Further, a medical examination on commencing work, elimination of weak men, but slight danger of injury from exposure to infected dust or exhaled spray, early going on the sick list, and the comparatively small danger arising from coal dust explain fairly well the reported figures. The serious increase of the death rate during the war was only apparent, for most of the strong miners...
were no longer at the mines and the manual labour was done by men sent back from active military service and by foreigners, especially Russians. Since then the death rate from tuberculosis has been below that reported during the war, although it is not as low as the pre-war figures, because the men are still weak and the new organisation (seven-hour day) requires a large number of men who are not carefully selected.

DEATH RATE FROM (a) ALL CAUSES AND (b) TUBERCULOSIS, CLASSIFIED ACCORDING TO THE TYPE OF WORK
(Rate per 10,000 Members of each Class)

<table>
<thead>
<tr>
<th>Class</th>
<th>1905 (a)</th>
<th>1914 (b)</th>
<th>1919 (a)</th>
<th>1922 (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clerks</td>
<td>67.11</td>
<td>57.84</td>
<td>100.34</td>
<td>60.00</td>
</tr>
<tr>
<td>Workmen:</td>
<td>82.90</td>
<td>63.61</td>
<td>93.39</td>
<td>67.71</td>
</tr>
<tr>
<td>Hewers</td>
<td>60.98</td>
<td>63.33</td>
<td>104.51</td>
<td>65.37</td>
</tr>
<tr>
<td>Timber men</td>
<td>83.47</td>
<td>57.45</td>
<td>59.93</td>
<td>48.10</td>
</tr>
<tr>
<td>Transport men</td>
<td>74.39</td>
<td>66.56</td>
<td>95.46</td>
<td>104.68</td>
</tr>
<tr>
<td>Others</td>
<td>86.90</td>
<td>74.05</td>
<td>75.49</td>
<td>44.99</td>
</tr>
<tr>
<td>Surface workers</td>
<td>72.99</td>
<td>78.33</td>
<td>83.18</td>
<td>71.39</td>
</tr>
<tr>
<td>Totals</td>
<td>64.61</td>
<td>66.66</td>
<td>90.18</td>
<td>68.31</td>
</tr>
</tbody>
</table>

It is necessary to be very careful before drawing conclusions from available statistics, for many different factors come into play. Thus, for example, the members of the insurance society of Bochum are chiefly drawn from an urban population, whilst those of Saarbruck and Tarnowitz are drawn from a rural population. Further, the conditions of work are different for the three districts in question, the work being harder in the west than in the east. The insurance societies of Bochum and Tarnowitz both include workmen in metalliferous mines, and the latter also includes workmen at metal furnaces. In the first case, only about 1.9 per cent. of members are not coal miners, in the second case 10.5 per cent. By way of contrast, in the insurance society of Saarbruck all the members are coal miners. Some women members appear in the three societies; their number was, in 1909, 0.9 per cent. in the Saar, 2.3 per cent. in Westphalia, and 9.5 per cent. in Upper Silesia. It is then impossible to obtain a uniform picture of the diseases of German coal miners. Similarly reservations must be made when comparing these figures with those of other trade groups.

According to statistics, the highest frequency of sickness is met in the Bochum district, where the scarcity of manual labourers is very considerable, so much so that it is necessary to employ workmen who are not trained, and that greatly increases the death rate. In Upper Silesia the number of notifications of diseases much increased since 1919, the year when compulsory hospital treatment was abolished.

Detailed statistics given by Heymann and Freundenberg (Essen, 1925) for the mining district of the Ruhr show that pneumonia is the disease which is the most frequent cause of death. This disease attacks especially workmen in the course of their first years of work. The death rate with them is higher than in the general population and its frequency increases with age more definitely than for the general population. Pleurisy is rarer and runs a more favourable course than pneumonia. The exact rates for bronchitis are not given, as its diagnosis is too often subjective. Fatal cases are, however, rare with adults. As regards influenza, the sickness rate is equal to that of the general population; it is particularly low for hewers.

In Great Britain a study by Collis of the mortality of miners aged from 25 to 64 years and covering the period 1910 to 1912 gives the following comparative figures:

<table>
<thead>
<tr>
<th>Class</th>
<th>All causes</th>
<th>Tuberculosis</th>
<th>Pneumonia</th>
<th>Bronchitis</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>All coalfields</td>
<td>514</td>
<td>36.4</td>
<td>66.4</td>
<td>66.4</td>
<td>38.4</td>
</tr>
<tr>
<td>All occupied and retired males</td>
<td>790</td>
<td>142</td>
<td>66</td>
<td>38</td>
<td>47</td>
</tr>
</tbody>
</table>

There is a marked difference between the death rate of miners employed on the various coalfields, even when the conditions and environment of work, the hours of work, etc., are almost identical. The mortality is high on all fields for accidents, and on most for
pneumonia and bronchitis. The mortality for tuberculosis, although quite different on the different fields, is comparatively low on all. The average age for deaths from tuberculosis is 37-38 years for hewers, and 30-31 for other underground workers, and 31 for those working on the surface. The hewers suffer from tuberculosis chiefly when they have worked a long period and always in a higher proportion than the other classes of miners. The death rate from pneumonia shows high figures in certain districts particularly among hewers; it is associated with high rates for bronchitis, and comparatively high rates for tuberculosis. Accidents are very frequent on all the coalfields and especially on the fields where the death rates from disease is highest.

The following figures may be quoted:

(a) DEATHS AMONG MINERS, INCLUDING THOSE RETIRED, ARRANGED BY AGE GROUPS AND BY OCCUPATION (PERIOD 1910-1912), AND (b) MEAN ANNUAL DEATH RATE PER 1,000 LIVING

<table>
<thead>
<tr>
<th>Class</th>
<th>15-19</th>
<th>20-24</th>
<th>25-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55-64</th>
<th>65-74</th>
<th>75 and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hewers (a)</td>
<td>428</td>
<td>536</td>
<td>2,015</td>
<td>2,360</td>
<td>2,713</td>
<td>3,464</td>
<td>3,965</td>
<td>2,182</td>
</tr>
<tr>
<td>... (b)</td>
<td>3.24</td>
<td>4.20</td>
<td>4.31</td>
<td>6.78</td>
<td>13.45</td>
<td>35.35</td>
<td>100.26</td>
<td>214.30</td>
</tr>
<tr>
<td>Other underground workers (a)</td>
<td>790</td>
<td>539</td>
<td>746</td>
<td>811</td>
<td>916</td>
<td>1,113</td>
<td>914</td>
<td>283.32</td>
</tr>
<tr>
<td>... (b)</td>
<td>3.21</td>
<td>4.18</td>
<td>4.78</td>
<td>6.76</td>
<td>11.46</td>
<td>23.30</td>
<td>59.89</td>
<td>280.32</td>
</tr>
<tr>
<td>Surface workers (a)</td>
<td>144</td>
<td>141</td>
<td>218</td>
<td>264</td>
<td>375</td>
<td>559</td>
<td>550</td>
<td>319</td>
</tr>
<tr>
<td>... (b)</td>
<td>2.79</td>
<td>3.58</td>
<td>4.54</td>
<td>5.03</td>
<td>10.75</td>
<td>22.30</td>
<td>49.29</td>
<td>218.32</td>
</tr>
</tbody>
</table>

The comparative mortality figures for various diseases among miners at ages 25 to 64 on all the fields for the same period appear for the three groups as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Tuberculosis</th>
<th>Pneumonia</th>
<th>Bronchitis</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hewers</td>
<td>85</td>
<td>67</td>
<td>60</td>
<td>112</td>
</tr>
<tr>
<td>Underground workers</td>
<td>60</td>
<td>62</td>
<td>36</td>
<td>158</td>
</tr>
<tr>
<td>Surface workers</td>
<td>65</td>
<td>59</td>
<td>45</td>
<td>85</td>
</tr>
</tbody>
</table>

In collieries where the galleries have a height of from 8 to 10 metres and allow miners free movements, the transport of coal from the face is carried out by means of tubs. In these cases signs of exhaustion are seldom seen among the workers.

The conditions of work dealt with above and the fatigue of the respiratory apparatus both cause exhaustion of the circulatory system, and, in the first place, of its central organ, the heart. Thus is set up a state of unbalanced equilibrium between the capacity of the organ and the work to be done, which shows itself by dilatation and hypertrophy of the heart. If the exhaustion continues too long, and if other personal conditions are added, such, for example, as alcoholism, it is not uncommon to find myocardial degeneration.

Amongst miners in deep level mines in Brazil, Freise found (1930) cases of paroxysmic tachycardia amongst newly engaged workers during the first days at work, some minutes, or at times some hours, after the commencement of work. This tachycardia was followed by arrhythmia, stronger heart beats, and general weakness. Whilst these symptoms disappeared in a few hours amongst Negro and half-caste workers, white workers suffer from the attacks for a period of several months. There was likewise noticed acute cardiac weakness resulting from physical strain.

E. and A. Dickson, impressed by the very high incidence of arteriosclerosis amongst young miners, carried out in 1929 a systematic examination of 500 workers and found arteriosclerosis in 85 per cent. of the young miners aged twenty and under. The arteriosclerosis in question was of a special histological type, and was never accompanied by high blood pressure or by subjective symptoms. These authors attribute this occupational arteriosclerosis to the time spent in the mine galleries, as the proportion of cases increased with the number of years spent at the coal face. Others consider that it is connected with the use of alcohol and tobacco rather than with fatiguing work—a cause which takes a second place.

Marked thickening of the superficial and visible arteries, especially of the upper limbs, should not be confounded with arteriosclerosis, which, according to these experts, cannot be regarded as an industrial disease of miners.
The temperature rises as one descends in a mine. In certain cases it may reach 30° C. and more (for example, 38.8° C. on the Lancashire coalfields, Great Britain). Further, the activity of the men and animals, the machinery and lighting, all increase the temperature and vitiate the air, whilst the degree of humidity frequently reaches the limit of saturation corresponding to the temperature. Remaining in these conditions becomes intolerable. Sweat, which is profuse, cannot evaporate; the heat regulating function becomes defective and symptoms similar to those of heatstroke occur. (See article “Air: Hot and Humid Atmospheres”.)

The enquiry of the British Government Commission, 1922, upon the conditions of temperature in hot and deep mines, extending over a period of three years, showed that the daily quantity of sweat of a miner increased considerably with a temperature above 21° C. With an average temperature of 37° C. the average quantity of water consumed daily by miners at Pendleton was 12 pints. On the contrary, in the coal mines of South Wales, where a temperature of 12.7° C. prevails, the small quantity of water consumed amounted to an average of 2.7 pints each day for each miner. The average quantity of sodium chloride consumed increases equally with the temperature: Pendleton, 16.9 grm.; South Wales, 12.8 grm.

In the warm mines of Pendleton, where the thermometer marks 36.6° to 38° C. and the hygrometer 28.3° to 30.5° C., serious attacks of muscular cramp, followed by profound exhaustion, have been reported, especially among miners of poor physique.

These cramps occur in the muscles which are the most fatigued (arms, legs, etc.), and are attributed to the high temperature, to work which is too strenuous, to an excessive consumption of water, and, according to Haldane, to the considerable elimination of salt by the sweat.

As a matter of fact, the miner does not wait to be attacked by cramp, and more often stops work as soon as he feels giddiness or headache. The
administration of sodium chloride, or of a mixture of 60 per cent. of sodium chloride and 40 per cent. potassium chloride with a little tartar, is a preventive (about 2 grm. per litre for a dose).

Freise (1930), who studied the pathology of miners engaged in the deep level mines of Brazil (Morro-Velho, New Lima), does not indicate the proportion existing between the total number of cases of sickness and the total number of workers involved. He gives the following percentages for various disease forms: respiratory affections, 30 per cent.; heart affections, 20 per cent.; digestive derangements, 19 per cent.; skin diseases, 14 per cent.; rheumatism, 9 per cent.; eye diseases, 4 per cent.; various affections of the ear, nose and throat, etc., 2 per cent.; amongst the diseases of the respiratory apparatus he distinguishes: active pulmonary hyperaemia, 56 per cent.; acute alveolar dilatation, 27 per cent.; chronic alveolar dilatation, 10 per cent.; hyperaemia due to stasis, 3 per cent.; other pulmonary affections, 4 per cent.

Miners easily become accustomed to high temperatures, although under certain conditions they may be threatened with failure of the heat-regulating function. Refreshing ventilation in mines is therefore necessary.

In the German mines, which are much less warm, attacks of spasmodic cramp are not known, and they can be easily avoided by reducing the day's work to 6 hours as a maximum when at the coal face and in places reserved for machinery where a temperature of 29° C. and more prevails (Germany: Mines Act, 1905; Police Regulations of the Westphalian mines).

Loss of fluid due to profuse sweating gives rise to dryness of the mouth and pharynx, and compels the miner to drink great quantities of water to quench his intense thirst, which often causes catarrh of the stomach and intestines. Strict rules must be enforced for ensuring a system of watertight pipes to convey drinking water into the workings, furnished with numerous taps, and for protecting the principal reservoir against impurities and infectious germs. Legislatures have even laid down regulations requiring that the water used for baths and for damping to prevent coal dust should be free of any risk to the health of the miners. In order to prevent miners drinking slop water, as is still done, care must be taken only to use closed conduits. The contamination of the

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FIG. 36. — The coal face of a mine in Upper Silesia.
whole of a mine by the germ of typhoid fever may, in certain circumstances, be due to cases among a single gang of men, or to the presence of germ carriers. Sudden cooling of the heated body by draughts, work in a cramped position, or lying on the cold ground, and the fact that the miner is drenched with sweat, often induce manifestations of muscular rheumatism. The miners then complain of local pains, twitchings and fatigue of the muscles. Cases of lumbago and sciatica are also very frequent. On the other hand, acute articular rheumatism is an infectious disease which has nothing to do with the miners' occupation. According to the statistics already quoted of Heymann and Freudenberg concerning the Ruhr, the death rate from circulatory diseases (including those of the urinary passages) is the same as that of the general population for the first years of work only; later it is lower. Diseases of the urinary passages cause death among miners in the age of twenty, with a frequency perhaps a little higher than among other groups of the population; but this frequency is lower among the older workmen.

Diseases of the digestive organs (7.3 per cent.) are no more numerous than those of the organs of respiration. They are due, at least in part, to the pressure and vibration which the compressed air tools exercise upon the stomach and liver, and to the ingestion of dust, etc. According to Lindemann, the same peculiarity is noticed as regards the death rate, that is, if infectious diseases are excluded. Cancer is not rare among miners; however, the English statistics of deaths according to occupation show for the miners' group, and for 100 years of life, a rate for any age which is certainly one of the lowest.

The digestive troubles may be explained by the climatic conditions of mining, especially when the men have not yet got accustomed to them. An explanation may also be sought in the psychological habit of declaring subjective troubles when medically examined (Heymann and Freudenberg). As to muscular rheumatism, the figures of different German insurance societies show great variations and suggest a suspicion of differences in diagnosis. The average figures available do not correspond with the true distribution of the disease.

The rates given by the local health insurance office of Leipzig are as follows: digestive system, 6 per cent.; respiratory system, 5.6 per cent.; rheumatism, 3.3 per cent. But all these figures should not be considered as exact, for 'internal diseases of occupational origin affecting miners are not yet well known.

The acute form of articular rheumatism is generally a more frequent cause of sickness than with other classes of the population. Heymann and Freudenberg are led to enquire why this cause is operative chiefly in the first years of work. In their view, it is explained by a greater incidence of diseases caused by cold and an insufficient acclimatisation to atmospheric and other conditions underground. In its turn, this frequency of rheumatism explains the very high mortality among the young men due to diseases of the heart and kidneys. (For lesions of the locomotor system, see article "Occupational Diseases: Locomotor System").

Generally, the experts, in noting an extremely slight mortality from chronic alcoholism, confess that this is an unexpected result. It should be borne in mind, however, that the alcoholic miner is not welcomed in a mine, for he is a cause of danger to his comrades.

The certified cases of alcoholism show the following rates in the Ruhr district:

<table>
<thead>
<tr>
<th>Year</th>
<th>Sick</th>
<th>Dead</th>
</tr>
</thead>
<tbody>
<tr>
<td>1919</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1920</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>1921</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>1922</td>
<td>30</td>
<td>7</td>
</tr>
</tbody>
</table>

The fact is that the miner never drinks during work. According to English statistics of 1910-1912, the comparative mortality rates for men aged 25 to 65 from alcoholism, distributed according to occupation are as follows:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Alcoholism</th>
<th>Alcoholism and disease of liver</th>
<th>All causes of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miners</td>
<td>3</td>
<td>13</td>
<td>727</td>
</tr>
<tr>
<td>Agricultural labourers</td>
<td>9</td>
<td>7</td>
<td>470</td>
</tr>
<tr>
<td>Dock labourers</td>
<td>26</td>
<td>43</td>
<td>1,127</td>
</tr>
<tr>
<td>All males</td>
<td>7</td>
<td>33</td>
<td>780</td>
</tr>
</tbody>
</table>

The observations in which Collis compares industrial unrest with the death rates on certain English coalfields are also interesting. Figures, drawn from districts voting a strike (August 1920), class the districts in the same order as the mortality rates: Lancashire, with a percentage of 90.6 votes in favour; South Wales, 77.9; Derbyshire, 71.8; Durham, 69.9, and Nottingham and Yorkshire with the lowest figures, 55.1 and 51.1 res.
pectively. In 1924 the figures for miners who voted against the wages agreement were as follows for the above districts: 94.3; 89.8; 76.8; 75.9; 69.2 and 75.1.

Nervous diseases are not very common, with the exception of nystagmus (see article "Miners’ Nystagmus") as it occurs in Great Britain and, associated with accidents, of a state of anxiety caused in certain individuals by the fear of accident which haunts them every instant in the mine.

Underground work prepares the way for a state of neurasthenia and irritability, while the use of compressed air tools has also been regarded as a cause of nervous troubles among predisposed persons (see article "Pneumatic Tools").

As regards tumours, Heymann and Freudenberg estimate that work in coal mines does not increase the risks; it seems rather to diminish them. Out of 10,000 living, 5.3 active and retired miners died from malignant tumours in the years 1920-1922, compared with 11.4 for males generally (Prussian statistics).

According to the statistics of the German Mining Association, including active members, the death and sickness rate showed the following figures (average for the period 1912-1920):

<table>
<thead>
<tr>
<th>Active members</th>
<th>Number of sick per 100 members</th>
<th>Number of accidents per 100 members</th>
<th>Number of deaths per 100 sick</th>
<th>Number of accidents per 100 members</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910</td>
<td>19.45</td>
<td>1.23</td>
<td>0.73</td>
<td>0.2</td>
</tr>
<tr>
<td>1911</td>
<td>14.6</td>
<td>0.85</td>
<td>0.47</td>
<td>0.11</td>
</tr>
<tr>
<td>1912</td>
<td>10.9</td>
<td>0.90</td>
<td>0.50</td>
<td>0.15</td>
</tr>
</tbody>
</table>

The same statistics give for various causes of morbidity and mortality per 100 active members of the association the following figures:

| Year | Digestive diseases | Respiratory diseases | Muscular rheumatism | Nystagmus | Adipositis-
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1913</td>
<td>8.8</td>
<td>7.0</td>
<td>8.4</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>1920</td>
<td>6.9</td>
<td>6.4</td>
<td>5.6</td>
<td>3.1</td>
<td>0.02</td>
</tr>
</tbody>
</table>

* Gastric and intestinal catarrh only.

1 Cf. pp. 251-252.

In the United States, an investigation by Hayhurst (1918) deals with the bituminous coal of the States of Ohio and Illinois, the first including 59,000 miners and the latter 90,000. The average annual death rate of Illinois miners has increased from 10.03 (1913) to 11.85 (1918); and during 64 years (1912-1918) for the different causes of death, over a yearly average total of 77,051 miners, the rates were as follows:

- Typhoid fever: 2.8
- Tuberculosis: 19.4
- Nervous diseases: 5.3
- Diseases of the circulatory system: 5.7
- Pneumonia: 9.1
- Other respiratory diseases: 3.9
- External diseases: 36.8
- Cancer: 3.8

It is interesting to notice that deaths from tuberculosis were highest among miners from 25 to 34 years, whilst the deaths from pneumonia show the highest rate in the group from 45 to 54 years.

An enquiry dealing with the period 1916 to 1920, for an annual average personnel of 25,764 miners in the State of Indiana, has shown that, out of 100 deaths, accidents caused 26.20, respiratory diseases 9.15, pulmonary tuberculosis 6.45, diseases of the heart 8.75 (14.05 for the general population), nephritis 5.94, cirrhosis of liver 1.09, cancer 3.51, apoplexy 3.28, and various other causes 7.48 (the general population).

For various reasons one cannot always rely on the age at which invalidity occurs as an index of the strength and state of health of miners. Mille has calculated that in 1909 the age of invalidity was 50.6 years for the miners of Upper Silesia, 48 years for those of the Saar and 46 years for those of Bochum. The period of service was respectively 23.3, 28.3 and 22 years. For Upper Silesia the average age of invalidity was 48.8 years in 1910-1912 and 49.3 in 1916-1920; for the insurance society of Bochum in 1911-1913 43.1 (average duration of service, 19.4 years), and 43.9 years in 1919-1921.

In conclusion, work in the mines cannot be regarded as very injurious to health, except for accidents which
are fairly frequent and sometimes fatal, due to catastrophes.

In Germany the mining insurance association of Bochum reported in 1908 and 1910 that 82.5 per cent. of accidents occurred among underground workers, who constitute in Prussia about 75 per cent. of all the coal miners. The most serious accidents are due to fire damp and explosions of coal dust, falls of rock and coal, the premature or delayed action of explosives, the bursting in of masses of water, the breaking of cables, the sudden opening of cages, falls into disused shafts, etc.

The German coal-mining industry shows fewer dangers than occur in the occupations of transport, building, iron furnaces and iron works, and woodwork. It may be classed almost in the same category as foundries and rolling mills, underground construction work, and flour mills.

According to the calculations of Dr. Frey, the district of the Saar shows the greatest frequency of accidents, whilst formerly it was the mines of Westphalia which headed the list. It is clear that a general catastrophe, or the recruiting of strangers to the trade, may cause the figures to oscillate and produce temporary variations. The number of accidents is much higher in these two districts than in Upper Silesia, because the conditions of work are much more dangerous and difficult in the former.

According to Lindemann, 69 per cent. of the accidents are attributable to dangers peculiar to the mining industry. It is certain in any case that the number of fatal accidents has considerably diminished in German mines. For 1,000 miners the accidents were as follows:

<table>
<thead>
<tr>
<th>Mining district</th>
<th>1909</th>
<th>1910</th>
<th>1920</th>
<th>1921</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westphalia</td>
<td>2.6</td>
<td>2.2</td>
<td>1.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Upper Silesia</td>
<td>2.1</td>
<td>2.0</td>
<td>1.5</td>
<td>—</td>
</tr>
<tr>
<td>Saar</td>
<td>1.3</td>
<td>0.9</td>
<td>1.0</td>
<td>—</td>
</tr>
</tbody>
</table>

The Local Health Office of Leipzig shows the figure of 0.25 per cent. for accidents (for male members).

A German statistical table for 1918 and 1919 gives the following rates:

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of workers</th>
<th>Injured</th>
<th>Per 1,000 members</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918</td>
<td>800,340</td>
<td>14,108</td>
<td>17.74</td>
<td>2,618</td>
</tr>
<tr>
<td>1919</td>
<td>967,060</td>
<td>14,117</td>
<td>14.58</td>
<td>2,472</td>
</tr>
</tbody>
</table>

According to an enquiry by Heymann and Freudenberg, accidents occur to this class of worker with a frequency which follows very closely that given for transport workers and exceeds the frequency of all other industrial classes. Fatal accidents are in the same proportion. Accidents occur more frequently to the underground gangs than to those on the surface. Those most affected are the hewers, then the haulage men; other underground workers are less affected, but suffer more than the surface workers. Fatal accidents occur most frequently to the hewers and then to the haulage men. Generally, the accidents are more frequent among young workers, and their frequency diminishes with age; the death rate from accidents, on the other hand, increases with age.

For the period from 1894 to 1915 it has been possible to classify the accidents according to the days of the week, and the following is the table (for 100 accidents):

<table>
<thead>
<tr>
<th>Day</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15.47</td>
<td>16.90</td>
<td>16.28</td>
<td>16.20</td>
<td>16.33</td>
<td>16.87</td>
<td>2.65</td>
</tr>
</tbody>
</table>

In the United States the collieries in 1922 employed 844,507 workers; and the number of fatal accidents was 1,979. In 1923 they employed 846,990 persons and the number of deaths was 2,452; whilst the loss of production by fatal accidents may be estimated at 241,006 tons in 1922, and in 1923 at 261,013 tons.

The accidents in the year 1922 were caused in a proportion of 1.81 (per million tons) by falls of rock, 0.71 by explosions due to gas in the mines or to coal dust, 0.19 by explosives. The accidents on the surface have only a figure of 0.24.

In Great Britain and in Ireland the number of fatal accidents was, during 1922, 0.95 for 1,000 persons employed, and in 1923 1.06.

Of 1,179 fatal cases reported among miners working underground 60 were caused by explosions of fire damp or of dust, 585 by slipping of coal-seams, 58 by accidents, 314 by means of transport, and 162 by various causes (1922-1923):

The following table gives the average of fatal accidents in the pits and at the pit-heads in the principal coal-producing countries:

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of workers</th>
<th>Injured</th>
<th>Per 1,000 members</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918</td>
<td>800,340</td>
<td>14,108</td>
<td>17.74</td>
<td>2,618</td>
</tr>
<tr>
<td>1919</td>
<td>967,060</td>
<td>14,117</td>
<td>14.58</td>
<td>2,472</td>
</tr>
</tbody>
</table>
MINERS' DISEASES

<table>
<thead>
<tr>
<th>Number of workers (annual average)</th>
<th>Number of fatal accidents (per 1,000 workers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium, 1920-1927</td>
<td>163,040.3</td>
</tr>
<tr>
<td>France, 1920-1926</td>
<td>209,043.9</td>
</tr>
<tr>
<td>Great Britain, 1900-1918</td>
<td>1,137,969.0</td>
</tr>
<tr>
<td>Nether lands, 1920-1928</td>
<td>29,210.7</td>
</tr>
<tr>
<td>Prussia, 1920-1928</td>
<td>500,555.4</td>
</tr>
<tr>
<td>United States, 1920-1928</td>
<td>511,580.4</td>
</tr>
</tbody>
</table>

PROPHYLAXIS

Generally all countries are anxious to ensure by law the best hygienic and safe conditions in their mines. (See article "Mines (Hygiene, in ")

Several of them have also published leaflets on the treatment of poisoning by fire damp, by after damp, and by coal dust, etc. Thus, for example, the leaflet published by the Health Office of the German Government shows the illnesses produced by these poisonous gases and gives necessary suggestions to doctors for proper treatment, for the use of oxygen, etc.

As regards tuberculosis, see articles "Gold Mines", "Stone Industry", etc.

With reference to the prevention of cellulitis and bursitis it must be borne in mind that the cause causans is always the same for the three forms: traumatism in direct connection with work. The knee is affected as a result of work carried on in thin seams or where the miner is compelled to work on his knees; the hand is affected by the use of picks with handles which are rough, or by getting hard coal.

These parts of the body must then be protected from repeated trauma, or its harmful effects must be diminished. Further, the entrance of infectious germs into the tissues of which the resistance is lowered should be avoided as much as possible. It is a question, it is true, of very common ordinary diseases varying from individual to individual: prophylaxis consists in avoiding all infection by keeping the skin clean and maintaining the system in a good state of health. In cases of infection it may be possible at an early stage to prevent development of trouble by early intervention, for example, by the application of tincture of iodine; later skilled surgical interference may be required especially if dealing with cellulitis of the hand. A good first-aid system should therefore be organised; workmen must be instructed; advice should be given against the wearing of garters worn below the knee; suitable knee pads should be used; rough pick handles should not be used. Douche baths should be installed. According to the report of Collis and Llewellyn (1924), there were in 1922 in the whole of Great Britain installations of douche baths only for 3,000 working miners, whilst the number of underground workers at this date comprised more than 950,000 persons.

An exhaustive investigation of the factors which cause pneumoconiosis in miners becomes more and more urgent. Some tens of thousands of hewers and drillers are exposed to a disease which reduces or arrests all capacity for work with the most serious consequences for the individual and the community. Every useful measure to remove dust or to lay it should be adopted without delay.

Certain recent British investigations have established that the group of men who work in mines on rocks containing free silica, particularly if they use percussive drills, are exposed to silica dust and contract silicosis just as are metalliferous miners.

The industrial diseases of miners which are compulsorily notifiable are as follows:

Netherlands: poisoning by arsenic, subcutaneous cellulitis of the synovial membrane of knee and elbow, dermatitis (eczema, etc.), nystagmus, inflammation of joints, skin and subcutaneous cellular tissue, ulceration of the cornea and conjunctiva.

| STATISTICS OF ACCIDENTS IN THE MINING DISTRICT OF THE RUHR |
|-------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Frequency of accidents (per 10,000 miners) | 1907 | 1910 | 1914 | 1918 | 1919 | 1920 | 1921 | 1922 |
| 177.5 | 171.5 | 194 | 211.8 | 223.4 | 190.2 | 118.7 | 102 |
| Deaths from accidents (per 1,000 living) | 2.3 | 2.9 | 2.2 |
| Deaths from accidents (per 1,000 miners) | 1.8 | 2.1 | 2.4 | 3 | 2.2 | 1.9 | 1.7 | 1.8 |
**MINERS’ DISEASES**

**Norway:** infections and complications of ulcers of the skin.

**Western Australia:** pneumoconiosis, miners’ tuberculosis, nystagmus, ankylostomiasis, dermatitis.

The following diseases are compensated when they occur among miners:

**Bulgaria:** ankylostomiasis, nystagmus.

**Canada:**
- Alberta, Manitoba, New Brunswick, Ontario: ankylostomiasis;
- **Australian** Silicosis, Silicopneumoconiosis, Silicosis, pneumoconiosis.
- **United States of America:** Silicosis, pneumoconiosis, dermatitis.

**China:** infections and complications of silicosis, pneumoconiosis.

**Great Britain:** nystagmus, subcutaneous cellulitis of the hand and knee, synovitis of the elbow, ankylostomiasis.

**Italy:** ankylostomiasis.

**U.S.S.R.:** serious anaemia due to ankylostomiasis, nystagmus, cellulitis of the hand, knee and elbow, cancer of the skin, pneumoconiosis.

**Venezuela:** cellulitis of the hand and knee, synovitis of the wrist, nystagmus.

**Western Australia:** for diseases which are compulsorily notifiable (see above) and in addition inflammation of the synovial lining of the wrist joint and tendon sheaths, ankylostomiasis.

**Queensland:** inflammation of the synovial membrane of wrist and tendon sheaths, ankylostomiasis, nystagmus.

**South Australia:** ankylostomiasis.

For compensation on account of silicosis in South Africa, and the province of Alberta, see articles “Tuberculosis—Silicosis” and “Gold Mines”.

The cases of industrial disease, in all forms of mining, compensated in Great Britain during the period 1920-1931, other than nystagmus, forms of cellulitis and bursitis were as follows:

<table>
<thead>
<tr>
<th>Diseases</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead poisoning</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Nitrous fumes</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Dermatitis</td>
<td>7</td>
<td>4</td>
<td>11</td>
<td>2</td>
<td>11</td>
<td>3</td>
<td>35</td>
<td>53</td>
</tr>
<tr>
<td>Ulceration of the skin</td>
<td>18</td>
<td>—</td>
<td>3</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Epithelioma</td>
<td>1</td>
<td>—</td>
<td>4</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Ulceration of the cornea</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>14</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Scrotal epithelioma</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Ankylostomiasis</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Writers’ cramp (clerical staff)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>9</td>
<td>13</td>
<td>29</td>
<td>16</td>
<td>35</td>
<td>37</td>
<td>53</td>
</tr>
<tr>
<td>Total (including cellulitis and nystagmus, etc.)</td>
<td>7,071</td>
<td>7,546</td>
<td>6,015</td>
<td>6,909</td>
<td>7,181</td>
<td>8,560</td>
<td>8,844</td>
<td>7,996</td>
</tr>
</tbody>
</table>

It is interesting to quote here the fatal cases and cases of disablement, as well as the sums of compensation (in pounds sterling) paid to miners affected by occupational diseases:

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of cases</th>
<th>Sum of compensation</th>
<th>Number of cases</th>
<th>Sum of compensation</th>
<th>Total for the mines</th>
<th>Total for all mines and industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921</td>
<td>1</td>
<td>£300</td>
<td>8,711</td>
<td>£205,637</td>
<td>£2,257,541</td>
<td>£5,500,295</td>
</tr>
<tr>
<td>1922</td>
<td>—</td>
<td>—</td>
<td>12,585</td>
<td>587,095</td>
<td>3,494,604</td>
<td>6,655,728</td>
</tr>
<tr>
<td>1923</td>
<td>11</td>
<td>189</td>
<td>15,706</td>
<td>564,924</td>
<td>3,910,061</td>
<td>7,134,996</td>
</tr>
<tr>
<td>1924</td>
<td>2</td>
<td>247</td>
<td>15,504</td>
<td>674,299</td>
<td>3,379,914</td>
<td>6,675,638</td>
</tr>
<tr>
<td>1925</td>
<td>3</td>
<td>115</td>
<td>15,770</td>
<td>609,654</td>
<td>3,775,547</td>
<td>6,642,380</td>
</tr>
<tr>
<td>1926</td>
<td>5</td>
<td>1,297</td>
<td>13,187</td>
<td>540,796</td>
<td>2,716,259</td>
<td>6,008,291</td>
</tr>
<tr>
<td>1927</td>
<td>9</td>
<td>299</td>
<td>12,273</td>
<td>488,335</td>
<td>3,014,161</td>
<td>6,315,293</td>
</tr>
<tr>
<td>1928</td>
<td>3</td>
<td>992</td>
<td>14,772</td>
<td>501,960</td>
<td>2,518,075</td>
<td>6,657,273</td>
</tr>
<tr>
<td>1929</td>
<td>3</td>
<td>830</td>
<td>16,126</td>
<td>488,207</td>
<td>3,050,827</td>
<td>6,628,915</td>
</tr>
<tr>
<td>1930</td>
<td>2</td>
<td>618</td>
<td>16,947</td>
<td>505,458</td>
<td>3,004,469</td>
<td>6,415,907</td>
</tr>
<tr>
<td>1931</td>
<td>1</td>
<td>260</td>
<td>16,828</td>
<td>540,005</td>
<td>2,954,189</td>
<td>6,087,307</td>
</tr>
</tbody>
</table>
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(Berlin).

Miners' Nystagmus


The visual apparatus of miners, and more particularly of coal hewers, is subjected to strain and repeated violent shocks from the time of going down (brisk changes in lighting, increase of pressure) and later to visual exertion (accommodation, fixation, etc.) demanded by work under bad conditions of lighting. (See the article "Occupational Diseases: Eyes").

The centripetal influences, visual, labyrinthine, static, etc. (light, sense of position), which daylight stimulates, to the normal release of the reflexes, which are centrally controlled undergo complete change and soon set up, in susceptible subjects, the phenomena of exaggerated fatigue showing itself in a nervous syndrome characterised by inco-ordination and exaggeration of the visual reflexes (Stassen).

The study of ocular fatigue and visual overstrain would be made much easier if the precise nature of these phenomena, generally morbid, were definitely settled. Unfortunately the biological problem of fatigue is far from being finally determined and at the present time the stage reached is purely hypothetical.

HISTORICAL

The first case of nystagmus was described in 1860. Rubberh, in 1872, described the phenomenon. According to Snell, however. Gillet, of Sheffield, is said to have diagnosed the disease in 1854. Thackrah, at any rate, wrote in 1855 of a disease of the eyes, particularly among miners, which, even obliged them to give up their work. In 1865-1867 cases of nystagmus were described by Popp-Muller, and in 1875 Bell Taylor made a study of nystagmus describing it as though it were a new industrial disease.

The pathogenesis of nystagmus has been successively referred to several causes, of which the most important are the following: the position which the miner has to take up during his work of hewing (Dransart, 1877); the upward direction of the eyes; defective lighting which, according to Romée (1878), was the principal cause of the trouble; poisoning by mine gases (carbon monoxide especially, insisted on by Pechdo, 1893) — a view repeated again recently by Robson and denied by Hal dane (1925); and "lighting" when combined with a faulty position of the miner during his work and with his eyes directed upwards (Nieden, 1894). All these theories have been later accepted or rejected by the different authorities who have been occupied with the problem of nystagmus. Thus, for example, in 1887 Jeafferson stresses position, and some time afterwards (1907-1919) Rutten took the view that nystagmus is a neurosis caused by the fatigue following on the dissociation of movements (flexion of the head, raising of the eyes). Nuel (1908) adheres to the view of Nieden; Court (1891) to that of Romée; and Butler (1914), Coulter (1914), Davies (1920), and others to that of poisoning by coal gas. Peters in 1907 and Trombetta in 1909 are of opinion, on the other hand, that nystagmus is of labyrinthine origin.

A series of enquiries carried out in Belgium and Great Britain have similarly resulted in progress in the study of this question. The Belgian official enquiry in 1907 on the hours of work in mines led
to the report presented by Nuel to the Academy of Medicine, in which he established the claim that nystagmus is an industrial disease of miners causing a real incapacity for work. Stassen's enquiry (Liège) dates from 1912 and that of Ohm (Westphalia) from 1912. The Congress of Ophthalmology, held in Oxford in 1912, was a triumph for the view that inefficient lighting in the mine led to the frequency of nystagmus: it is the view of Stassen, Elworthy, Llewellyn, and Ohm. In the same year Coppex attributed nystagmus to an incomplete tetanus and sees it in the result of fatigue, not only of the elevator muscles of the eyes, but also of convergence. While Dransart (1913) considers that deficient lighting in the mine is a secondary pathogenic cause, and while Wilson (1913) thinks the disease is due to imperfectness of the retinal images, and Shuttlebotham (1914) to defective lighting and refractive errors, Stassen finds a sufficient cause of the ocular troubles affecting miners in the prolonged work under bad conditions of light.

In 1916, Ohm presented his theory of labyrinthine disturbance; he considers that predisposing causes such as alcoholism, stature, light heterophores, etc., play an important rôle. Nystagmus, according to this author, is a disorder of tone, produced by the labyrinth in different muscles or groups of muscles. The cause of this disorder is said to be lack of light and other unfavourable conditions of work.

Several reports, English and Belgian, have been published since 1912; the report by Collis and Llewellyn appeared in 1923. At first nystagmus was regarded as a local myopathy (of the elevators of the eyeball) or as the result of fatigue of the ciliary muscle of accommodation; to-day this disease is ascribed rather to a general fatigue of the whole of the oculo-motor system or as a general neurosis with local manifestations of the said oculo-motor apparatus (Stassen, Llewellyn).

In other words in miners, especially among hewers working under unfavourable conditions of illumination, a fatigue of the visual apparatus exists which may remain localised to the light perceiving elements (hemeralopia, defective retinal adaptation), but which very often passes this stage and extends to the centres controlling the muscles of the eye (nystagmus) and the reflexes protecting the eyes (blepharospasm) (Stassen).

The resulting visual troubles go on increasing more and more and finally set up, in hewers principally, psychical disturbances through exhaustion of the central nervous system (amblyopia, tics, neuroses).

ETIOLOGY — PATHOGENESIS

Before even entering into details the different kinds of illumination in coal mines must be studied. Illumination is provided by candles, by safety lamps supplied either from oil or petrol, by acetylene or electric lamps.

The luminosity of a candle flame varies very much according to the quality of the tallow: it is not constant, the flame flickers, and the light is yellowish. The oil safety lamp gives a flame which diminishes rapidly and cannot be trimmed by the miner. It becomes choked easily and yields a light which gets feebler and feebler (from dust, smoke, etc.). The flame flickers and its colour is reddish. The petrol lamp gives a flame the luminosity of which is twice that of the oil; its intensity is pretty constant; if necessary, the miner can trim the wick and regulate the flame which unfortunately is not sufficiently steady as it is sensitive to air currents. Often its glare annoys the miner; also the glass of this type of lamp gets dirty easily (dust, etc.).

The electric light alone offers remarkable advantages, but at present it is not widely enough used.

The coal face absorbs a large part of the luminous rays: this is why illumination can be improved by dusting the walls of the roadways with lime, talc, etc.

The problem of the etiology of the visual defects of miners can be stated, according to Stassen's views, as follows:

Given exposure of a normal, or apparently normal, human being to the following conditions:

1. acute or chronic poisoning by mine gases;
2. abnormal positions of the body (work in low roadways) entailing a state of general fatigue;
3. abnormal and repeated irritation of the labyrinth;
4. fatigue of the eye muscles, especially of the elevator muscles;
5. defective lighting,

it is necessary to determine which of these conditions is capable of setting up the syndrome of visual overstrain among the miners.

By statistical and clinical study, aided by laboratory experiments, Stassen has tried to fix as exactly as possible the rôle which each one of the conditions of work described above plays in giving rise to the visual defects of the miners. After eliminating those cases in which one only of these conditions could be accounted the sole cause of the malady, he was able to convince himself that the neces-
Sary and sufficient cause of the visual troubles among miners is prolonged work under bad lighting conditions.

His conclusions are that:

(a) Nystagmus is met with in miners where the only etiological factor, to the exclusion of all else, is work under bad conditions of illumination (by means of candles, oil cressets (crassets à l'huile), and oil or petrol safety lamps).

This is the case with the prop carriers, those who lead the horses, and the couplers, among whom up to 10 per cent. are nystagmic.

However, the height of the roadways and trolley-runs is from 1.80 to 2 metres and more; the workers can stand upright and rarely have to elevate their eyes or turn them from side to side. Further, they breathe fresh air which is drawn in by the extraction fans and has not been vitiated by the mine gases. Nystagmus is found among the couplers working at a relatively slight depth (100, 150, 180 metres) where labyrinthine irritation set up by increase of atmospheric pressure can be held to be nil.

(b) Nystagmus is not found among miners who have to use their elevator muscles to a fatiguing extent, but, on the other hand, work under relatively satisfactory conditions of illumination (acetylene lamps with reflectors, fixed incandescent lamps).

Enquiry made in slate quarries where acetylene lamps have been in use for a dozen years yielded no case of nystagmus, not even among those cutting at the face or among the labourers who have to go up ladders carrying blocks of slate weighing sometimes 100 to 150 kg. These men, however, work most of their time with the line of sight below the horizontal plane. The same result obtained in iron and zinc mines where acetylene lamps with reflectors have been in use for many years, and nystagmus is reduced to its most simple expression and that even among the hewers and timber men.

Among the two last-named parties of workers, Stassen found no evidence of oscillation of the eyeballs in any who had used acetylene lamps throughout their professional life. On the other hand, among men over 40 years of age who in their youth had worked for a long time with candles he found some cases of nystagmus, but slighter the longer they had used acetylene lamps.

### Number of cases of nystagmus per 1,000 workers

<table>
<thead>
<tr>
<th>Using</th>
<th>Severe cases with general neurosis</th>
<th>Definite cases (oscillation of the eyeball)</th>
<th>Per cent. of workers examined at their work not found to be suffering from nystagmus and using the lamps indicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety lamps</td>
<td>3.5</td>
<td>57</td>
<td>31</td>
</tr>
<tr>
<td>Fatty oil petrol lamps</td>
<td>1.2</td>
<td>13</td>
<td>15.4</td>
</tr>
<tr>
<td>Electric lamps use for two years</td>
<td>8</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Acetylene lamps used for two years</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Naked lights (lamps, and candles)</td>
<td>—</td>
<td>13</td>
<td>—</td>
</tr>
</tbody>
</table>

Hewers and timber men affected with definite nystagmus in coal mines find the condition improve or even disappear completely when they take up employment for several years as hewers and timber men in metalliferous mines or in phosphate mines where lighting is effected by means of acetylene lamps with reflectors, but where, on the other hand, their work remains unaltered as regards the life underground the elevator muscles of the eyeball are fatigued.

These facts are at variance with the theory of Dransart who considers that improved illumination could not cause the disappearance of nystagmus, which is mainly due to fatigue of the muscles of the eyeball.

(c) Finally, improvement in illumination exercises a favourable influence on the frequency and development of nystagmus. No case of nystagmus has been reported among the quarrymen and labourers in slate quarries, the hewers and timber men in zinc and iron stone mines using acetylene lamps with reflectors for about ten years, nor among the couplers, ostlers and machine hands in coal mines employed for at least three years in places illuminated by electric incandescent lamps of 32 and 64 candle power.

In conclusion, the necessary and sufficient cause of the visual troubles among miners, including nystagmus, according to Stassen, is prolonged work under defective conditions of lighting at the bottom of the mine. Improvement in lighting minimises and may even cause the entire disappearance of the troubles due to the ocular fatigue of miners.

These conclusions have been confirmed by the official enquiry in English and Scotch mines instigated by the British Government since the war.
The committee, among the members of which were Professor Pooley, of Sheffield, and Dr. Lister Llewellyn, of Newcastle, has given an admirable account of nystagmus and of the fatigue of the visual apparatus in miners.

From the etiological point of view the English committee was unanimous in recognising as the essential factor in the production of miners' nystagmus defective illumination (the other factors, such as the position assumed during work, accidents, alcohol, infection, heredity, predisposition, and errors of refraction, are only of secondary importance, and, on the other hand, the depth of the workings, the thickness of the seams, injurious gases, and mine ventilated air do not exert any direct influence on the disease), and that defective illumination is due to the feeble lighting power of the safety lamps in use in coal mines.

The importance of certain questions of interest, especially in relation to the physio-pathology of the eye and its connections in relation to too feeble lighting, has been given prominence recently (1925) by Haldane.

Taking the two enquiries together, the fact is abundantly made clear that to combat nystagmus and generally the pathological symptoms due to fatigue of the visual apparatus observed in miners, effort must be made more and more to increase the illuminating power of the safety lamps and to demand more light, always more light, at the bottom of the mine.

Thanks to the use of reflecting acetylene lamps, the disappearance of nystagmus is a fait accompli in metalliferous mines. Thus, for example, in the metalliferous mines of Sardinia, where for twenty years only acetylene lamps have been used and where the miner is not obliged to direct his eyes into an abnormal position, nystagmus is quite unknown (Biondi). Examinations must, therefore, be directed to ascertaining whether these lamps cannot be used in coal mines also, and the problem of the etiology of the visual troubles of the miners must be made the subject of more thorough investigation, and efforts made to determine, in regard to defective illumination in the deep workings, exactly the factor or factors capable of setting up these troubles.

This defective illumination in the deep workings may cause the condition by reason of:

1. A too feeble illuminating capacity of the lights used;
2. Defect in the steadiness of the lights;
3. The colour (predominance of certain luminous rays of the lights);
4. Insufficient protection of the miners' eyes against the lights.

The acetylene lamps used in the metalliferous mines have high luminous power (8 to 15, and even more, Hefner units). Naked, they burn with a clear and strong flame, producing an agreeable, quiet and steady light. Currents of air in the roadways and atmospheric humidity exert but little influence on the acetylene flame. Further, the eyes of the workers using acetylene lamps are protected against the glare by a reflector. Unfortunately, the use of cressets with uncovered flame cannot be entertained for use in coal mines. At the present, only one coal mine in Belgium is still allowed to use naked candles and oil lamps. All the other companies are compelled to illuminate their workings by means of so-called safety lamps.

Further, three other factors have to be taken into account: the medical man (diagnosis), the workman (auto-suggestion) and the surroundings.

Bartels and Knepper (1930), as a result of research into miners' nystagmus, have criticised, to begin with, existing statistics, which they affirm are confined to information about those patients who demand medical examination themselves at the pit-head. These authors have based their conclusions on English and German data and are convinced that the figures established in these countries have suffered the influence of economic circumstances to a considerable extent. Thus in the Ruhr mines (1922), out of 530,000 miners, there were only 31 reported to be suffering from nystagmus, whilst in 1928 out of a total of 380,000 miners the total cases of nystagmus amounted to 1,600. They found that in Germany the number of cases of nystagmus increased in proportion to the decrease in the number of workers occupied in the mine, whilst in Great Britain the two sets of figures are parallel.

In their study Bartels and Knepper report that in a well-lighted mine gallery where soft coal was mined they found 5.2 per cent. of cases of nystagmus, whilst in a mine where lean coal was worked, which was badly lit (lighting by benzine) and in which working conditions were difficult, the percentage was 10. Research carried out in the Ruhr showed 272 workers to be suffering from nystagmus, whilst of these only 3 presented themselves for
examination at the pit-head on account of the disease in question.

Workers engaged in repair and in hewing of coal showed the highest incidence for nystagmus. On the other hand, stone cutters were not affected, which points to the fact that the use of modern machinery cannot be considered as an important factor in regard to nystagmus.

The majority of underground miners affected by nystagmus were examined at the pit-head: in the case of a certain number the trouble disappeared on return to daylight. On the other hand, the majority of underground miners did not suffer from subjective troubles, and visual acuity appeared at least to be in no wise affected, for there is no certain method available providing an exact estimate of the effect of nystagmus on vision.

Nystagmus can be overcome in certain rare cases by the will of the patient; on the other hand, it can never be simulated; nevertheless, latent nystagmus can be caused to appear either by raising of the blood pressure (effort, etc.) or by modification of the pressure of the spinal fluid; such changes in pressure may occur in course of work.

STATISTICS

Belgium. — In Belgium Stassen's enquiry (1914-1919) has furnished the following data:

Among 20,000 men examined 5,000 were found suffering from nystagmus (25 per cent., of whom 8 per cent. were slightly affected, 12.5 per cent. suffered from transient fatigue, and 3 per cent. were severe; 1 per cent. only of the miners were affected by ocular overstrain and 0.2 per cent. with general exhaustion).

The frequency of nystagmus according to duration of employment was as follows: 2.5 per cent. for a period of 1 to 5 years, 4.5 per cent. from 6 to 10 years, 12 per cent. from 11 to 15 years, 24 per cent. from 16 to 25 years, 30 per cent. from 21 to 25 years, 40 per cent. from 26 to 30 years, 45 per cent. from 31 to 35 and 50 per cent. from 36 to 45 years.

Whilst nystagmus has been found in a proportion of 25.4 per cent. among miners working with oil lamps, and 20 per cent. in mines lighted by electricity, it has reached a percentage of 19.7 in mines lighted with naked lamps, of 8 in an iron stone mine and 5 in a zinc mine.

In state quarries lighted by acetylene lamps no case has been reported.

Nystagmus affected workmen on the day or night shift in accordance with their occupations in the following proportions:

<table>
<thead>
<tr>
<th>Occupations</th>
<th>Day per cent.</th>
<th>Night per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hwears</td>
<td>46.6</td>
<td>22.5</td>
</tr>
<tr>
<td>Overlookers</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>timbermen and repairers</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>Drillers and perforating attendants (Liège)</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>Bogeymen</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Couplers and conductors</td>
<td>6</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Statistics of Dransart for France give for 1913 a proportion of from 12 to 20 cases of nystagmus per 100 workers underground.

Germany. — In Germany (Westphalia) cases of nystagmus numbered 788 in 1918, 322 in 1919, 135 in 1920, and 51 only in 1921. The mining district of Westphalia has a mining population of about 190,000. The smallness of the numbers may be explained by the use of electric lamps, acetylene lamps, etc. A Prussian committee to investigate nystagmus has quite recently resumed its activities, so that shortly exact information will be available. The walls of galleries which have to be utilised for a long time are whitened with lime (Frey).

In the mining district of the Ruhr the careful inquiry by Heymann and Freudenberg (1925) has furnished the following figures per 10,000 workers:

<table>
<thead>
<tr>
<th>Year</th>
<th>1907</th>
<th>1910</th>
<th>1914</th>
<th>1918</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Night</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Nystagmus affects in general the age group from 30-50 years and notably the workmen at the bottom of the mine and among these the hewers. The invalidity per 10,000 workers caused by nystagmus is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>1907</th>
<th>1910</th>
<th>1914</th>
<th>1918</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>7.1</td>
<td>7.1</td>
<td>7.1</td>
<td>7.1</td>
<td>7.1</td>
<td>7.1</td>
<td>7.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Night</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

It affects especially men at the age group from 50 years and above.

Lindemann finds a percentage of 5 from nystagmus; Nieden, of Bochum, one of 5 to 7; and Ohm, of Bothrop, has reported from 1908 to 1925, 1,400 cases of nystagmus.

Great Britain. — According to Dransart (1877), A. Graefe is said to have seen only 3 cases of nystagmus; Ch. Bell, of Nottingham (1875), only found 3 cases. Recently (1925) Freeland Fergus stated that at the ophthalmological clinic of Glasgow when he was a medical student cases of nystagmus were rare and at that time there was no compensation.

Of 2,400 cases of nystagmus among English miners, 1,510 were coal hewers, 221 timbermen and repairers, 118 landers, etc. Of the 1,510 miners in question, 405 have worked a long time as hewers, 486 fairly long, 560 not long or not at all. About 50 per cent. thus fell in the "not long" or "not at all" class.

Of 1,613 colliers those who worked a very thin seam showed no case of nystagmus; 1 case among miners working a seam of less than 60 cm.; 66 in a seam of...
In slight cases of visual fatigue, Stassen says, these troubles of muscular equilibrium of the eyes ordinarily only occur on looking upwards, which is relatively the most difficult ocular movement to accomplish. But if, as a consequence of the necessities of the case, the miner overtaxes his eyes, the troubles increase in intensity. Using his eyes then on the slightest pretext (light reactions, static reactions, fixation reflexes, reflexes of convergence) the clonic spasms appear with each wider use of the field of vision; finally it becomes permanent in all positions of sight. Later, the clonic spasms are not limited to the ocular muscles, but sometimes reach the palpebral muscle (blepharospasm), the muscles of the forehead and of the face (tic) and reach even those of the nape, neck, trunk, etc.

In the effort to co-ordinate as much as possible their visual impressions in the midst of the nerve storms which affect their ocular centres (Nuel), the miners, when affected by severe forms of visual fatigue, require to make superhuman efforts of will power. Under such circumstances the trouble extends to a certain extent to the whole nervous system, etc., and after having exhausted all their stores of energy, these overstrained individuals succumb to amblyopia, and the neurosis which attends nystagmus.

According to the predominance of such and such symptoms as correspond with troubles of the centripetal impulses of the visual apparatus, with those of the neuro-muscular system of the eyes (centrifugal paths of the visual apparatus), or with those of the centres in the cerebral cortex, Stassen believes that he can distinguish the three following forms despite the clinical polymorphism which cloaks the nervous syndrome in miners working under conditions of defective illumination:

1. The retinal form: An early form or one which occurs when the malady is passing away, characterised notably by an affection of the light-perceiving elements of the visual apparatus. Principal symptoms: defective retinal adaptation (hemeralopia);

2. The clonic forms which affect the centrifugal paths of the visual apparatus (oscillation of the eyeballs, occupational nystagmus and blepharospasm);

3. The psychical forms characterised by affections of the cerebral system.
functions. Amblyopia and the neuroses of the coal miner are placed under this heading.

The malady may show itself in a slow form in which the miner is not sensible of subjective troubles, has no knowledge of oscillation of the eyeball, and is not incapacitated from work; and an acute form which can present three stages: slight, with very little incapacity for work; moderate, where underground work has to be abandoned (this is the ordinary form observed); and severe accompanied by total incapacity.

The first subjective symptom marking the onset of the malady is failure of sight, especially noticeable in the dark when delicate work has to be performed. This diminution, which continues on the surface, is worse at night, early in the morning and during twilight. It is a hindrance to the miner in his different movements, affects his sleep by violent headaches and nightmares; gradually, although at times with striking suddenness, vertigo and temporary loss of sight follow exertion and stooping.

This period is characterised by the following symptoms: diminution of sight, especially in the dark, occipital headaches, giddiness, after effort or after wounds, sometimes loss of sleep and photophobia. Nervous and even hysterical symptoms may appear, and if at this moment objective symptoms have almost disappeared, the subjective are always very marked.

The symptomatic triad is constituted by diminution of sight, headache and giddiness.

Diminution of sight is marked at night time so much so that the men working on the afternoon shift are often met on leaving the shaft by friends or parents to take them home. This loss of acuity would seem to be due to deficiency in adaptation to the dark. Among 1,330 cases examined by the British committee of enquiry, sight testing showed 57 per cent. with less than 3/12 vision at the acute stage of the disease (the test was only carried out when oscillation of the eyes was absent). Ohm found similar figures for 75 per cent. of the miners examined. The nystagmic has a feeling that surrounding objects are dancing and that the lamp dances. Although this feeling is pathogenic when it is present, subjects without a very marked rotatory oscillation of the eyes may not experience it.

The visual troubles bring in their train headaches generally situated at the occiput, but often temporal and sometimes ophthalmic. These headaches are made worse by effort, flexor movements of the trunk, or bright light. A characteristic of the malady is the persistence of inveterate and severe headaches, even after the miner has ceased work in the mine for some years. They seem to be the result of the development of a psycho-neurosis.

Giddiness soon adds itself to the first symptoms and develops along with them. They increase with efforts, bending or sharp turning movements. In severe cases the patient becomes ataxic and cannot move himself without assistance; photophobia, linked up very often with lid spasm, is associated with these symptoms. As the disease develops, mental symptoms appear showing themselves in marked mental hebetude with restlessness and insomnia at night, acute depression and fits of weeping ending in neurasthenia, neurosis with constant headaches, sleeplessness, anxiety, nightmares, marked mental depression, loss of memory, etc.

**Diagnosis**

Diagnosis is often made on noticing the special attitude of the patient from a distance. The walk of the nystagmic is often characteristic. The body stoops, the head is lowered, the eyes screened and the face is totally lacking in expression. Closer examination detects a slight tremor of the head (often resisting extension of the nape of the neck) and a rotatory oscillation of the eyeballs when the patient looks up. This oscillation, obvious in serious cases, can be elicited on asking the patient to look at a near object, to raise the eyes or to lower his head rapidly. These oscillations on the other hand are diminished or cease during repose, when the eyes are protected, or when the patient looks downwards. The movements are frequently associated with lid spasm (involuntary, persistent, synchronous), with photophobia, ascent of the eyeballs under the upper eyelid, with an intense convergent strabismus, lateral fixation and, in many cases, with slow half involuntary movements of the eyes. Oscillation of the eyeball is always present at one or another stage of the malady, but its demonstration is often difficult and requires at times repeated examinations after exercise or a stay in the dark. The rapidity of the movements is from 100 to 350 oscillations a minute — sometimes even more (Ohm: 150 to 400, 70 per cent. of the cases are between 250 and 350; Stassen: 90 to 360). The extent of the oscillations varies greatly; the amplitude is small when the rapid-
ity is high, and inversely. The gravity of the case can be gauged by the amount of elevation of the eyes in daylight required to induce oscillation. This test has a certain value despite the reservation to be attached to it. Differential diagnosis must be made with senile and alcoholic tremor.

**Course**

The clinical course of this fatigue depends on the state of general health and of the physiological personal resistances. Periods of exacerbation and remission occur. Thus symptoms are increased with intercurrent maladies (pneumonia, typhoid fever, etc.) which leave general debility behind them. Badly-nourished workers enfeebled by toil and privation, with large families, are a ready prey to severe forms of the disease. Relief of the general condition, rest, and good food exercise naturally a favourable influence on the course of the disease.

Miners’ nystagmus may be latent for years or gradually take on the acute form. Even when aware of his condition the miner may continue to work for years and a state of equilibrium be set up in which he is able to ignore the eye symptom. This fact is well known and it has even been suggested that he should educate himself after the onset of the first symptoms to accustom himself to them. While certain persons remain incapable of resuming work below, others can take up work in the roadways, but often as labourers only or as assistants’ repairers. Complete cure with resumption of work at the coal face is frequent, however, are frequent and each relapse makes the chance of resumption more remote.

In describing the course of the disease the British committee also distinguishes three principal types:

1. the atonic;
2. the spastic;
3. the psychic.

The first is characterised by loss of sight, headaches, giddiness and oscillation of the eyes. In the spastic form the patient has blepharospasm, photophobia, head tremor and severe headaches. The oscillation of the eyeballs is often difficult to elicit. The psychic form is characterised by the development of a neurosis or psychoneurosis with generalised tremors, nervous asthenia, functional heart troubles, headache, symptoms presenting the clinical picture of a traumatic neurosis or of “war-strain” (nervous exhaustion) shown by soldiers in the war.

The English report concludes that these three clinical types correspond generally to the retinal forms, clonic and psychic, which Stassen has described, of the fatigue of the visual apparatus in miners.

**Prophylaxis**

While improvement in lighting has been possible in the metalliferous mines, the difficulties of management, the presence of inflammable gas and especially of fire damp unfortunately make the use of lamps with a naked flame or of fixed electric lamps impossible.

It is however necessary to investigate whether there are no means, in the present state of lighting in coal mines with safety lamps, of improving the illumination and avoiding the visual troubles induced. It is, therefore, necessary to examine whether it is possible to increase the luminous intensity of the lamps, to give sufficient fixity and an agreeable colour to the sources of light, at the same time protecting the miner against glare and flickering.

In several ways electric lamps have made sensible progress, but their luminous intensity is still too feeble. Further, as compared with oil or petrol safety lamps, they have the great disadvantage of giving no warning to the miner of the presence of fire-damp and in many fiery coal mines, where electric lamps are used, it has been necessary to give the miners a second lamp of the safety kind to serve as an indicator of the presence of fire-damp, thus notably increasing the cost of lighting.

In Great Britain also interesting experiments have been made as to the lighting of roadways, and in order to increase the intensity of illumination the method of whitewashing the woodwork of the workings with milk of lime has been adopted. The miners’ eyes, too, ought to be protected from glare and flickering. With this object the British committee recommend the miners to fix their lamp above their cap.

The happy effect on the sight of the hewers and overmen of interposing a little screen of parchment between the fixing and the glass of the lamp has often been observed. This method of protecting the eyes could easily be extended because it would suffice if a
part of the glass of the lamp was made of matte.

To complete the history of progress in lighting there should be mentioned the experiments made in some Belgian and English mines, the object of which was to try and make the light pleasanter by using glass in the lamps of a yellow colour to cut off the blue and ultra-violet rays from the miners’ eyes.

Such protection of the eyes against glare, flickering, and injurious rays from the sources of light have not yet reached finality in coal mines, and it would be of great advantage to carry out further investigation in regard thereto.

Watch should be kept over the nystagminics because advice can be given to them as to certain precautions and practices which could prevent aggravation of their troubles.

As a precaution against hemeralopia, it would be worth while to recommend adoption of the practice of adapting a screen of parchment to the lamp; miners should wear dark goggles for some minutes both when going up and before descending in the cage in order to accustom their eyes to the changed lighting conditions and to avoid retinal shock provoked by the rapid passage from darkness to light and vice versa.

The ears should be carefully examined because lumps of wax are frequent and sometimes give rise to labyrinthine disturbance aggravating and complicating slight occupational nystagmus.

The general health should be attended to; tonics are here indicated.

In pronounced cases the worker would do well to take a less arduous task. Hewers and overmen of timbermen have seen their visual troubles notably improved by changing places; for example, some have asked to change their day shift for the night shift when the work is quieter and less intense.

Others have become couplers, conductors, or dillymen. They have been thus occupied in the wide workings in the trucking areas where circulation is easy and lighting sufficient — very much better than at the coal face, since almost throughout it is lit up by means of incandescent lamps of 22-64 candle power in much well-lighted places, after three or four years complete disappearance of nystagmus can be hoped for. Employment, therefore, of coal miners affected with pronounced nystagmus on surface work only is not absolutely necessary (Stassen).

On the other hand, some patients find work on the surface rather prejudicial to a cure because the miner likes his work below. The only work suitable for pronounced nystagminics who want to work at the surface is as lamp cleaners and caretakers, or some occupation not requiring excessive movement of the head or body. In severe forms of visual overstrain, complicated with amblyopia and neurosis, the patient must give up all work and rest several weeks — perhaps several months. Psychotherapeutic treatment (sometimes even as an in-patient in a hospital) is indicated.

The first duty of the medical man when confronted with this neurosis is, above all, to assure the miner that the infirmity is not final, but, on the other hand, that a cure is certain; they must be given confidence in themselves and anything that would tend to discourage this idea must be assiduously avoided.

Thus only can these victims of their occupation be given the power to resume work and become useful members of society (Stassen).

A study by Liewellyn suggests quite a series of measures to limit or prevent incapacity from work for nystagminics: Preliminary examination of the eyes on commencement of work; employment of semi-invalids on surface work; power to appeal periodically to expert medical referees; automatic and gradual lessening of the amount of compensation paid; payment of a lump sum in place of an annual sum; institution of medical services in schools for vocational guidance to select boys for work carried on underground.

### Legislation

Nystagmus is statutorily notifiable when affecting miners in Netherland's and in Western Australia (1924). It is scheduled under the Workmen’s Compensation Acts in Great Britain, Western Australia (mines and quarries), New South Wales, Queensland, the States of Minnesota and New York, and Russia. Nystagmus was added in 1907 to the list of scheduled diseases under the British Workmen’s Compensation Act, with the description “Nystagmus: Miners”. In 1913 this description was modified as follows: “The disease known as miners’ nystagmus, whether occurring in miners or others, and whether the symptom of oscillation of the eyeballs be present or not: Mining”. This definition may, however, be further modified (1926). Statistics show that the frequency of this disease has greatly increased since it was included under the Workmen’s Compensation Act, and especially after the extension given in 1913 to the description (Liewellyn). Economic post-war conditions have also played an important part in the increase of cases of nystagmus. The eco-
nomic loss caused by this malady in Great Britain is estimated at about a million pounds sterling yearly.

The number of cases of nystagmus which received compensation in Great Britain is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases compensated during the year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Old cases</td>
</tr>
<tr>
<td>1910</td>
<td>693</td>
</tr>
<tr>
<td>1912</td>
<td>1,818</td>
</tr>
<tr>
<td>1914</td>
<td>3,318</td>
</tr>
<tr>
<td>1920</td>
<td>4,163</td>
</tr>
<tr>
<td>1922</td>
<td>5,069</td>
</tr>
<tr>
<td>1925</td>
<td>7,533</td>
</tr>
<tr>
<td>1926</td>
<td>8,270</td>
</tr>
<tr>
<td>1927</td>
<td>7,534</td>
</tr>
<tr>
<td>1928</td>
<td>7,265</td>
</tr>
<tr>
<td>1929</td>
<td>7,265</td>
</tr>
<tr>
<td>1930</td>
<td>7,797</td>
</tr>
<tr>
<td>1931</td>
<td>8,333</td>
</tr>
</tbody>
</table>

Further numerous cases receiving compensation continue from one year into another: 3,741 in 1917; 4,163 in 1920; 4,804 in 1921; 5,055 in 1922.

In New South Wales, 42 cases were compensated in 1920-1923 among 350 cases of occupational disease. They received £6,889 out of a total of £77,643.

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1 This report especially has served as the basis for the present article.

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Mines (Hygiene in)


GENERAL

Mines (this term comprises the working of deposits of alluvial iron ore, pyritic and aluminous earths and peat, etc.) may be worked in the open or in subterranean channels.

Once the ground covering the deposit has been removed, the open mine is worked by means of successive trenches or terraces. In the case of deposits which are not of great depth, inclined horizontal galleries, descending or ascending as the case may be, are utilised. The descending galleries reach the ore bed by means of vertical shafts which facilitate the working of various veins or layers at different depths (levels) by means of horizontal galleries. The workers attack the seam or vein or bed of the deposit at different points known as the "working face" or "headings".

Work at the bottom of the mine is not infrequently effected by three shifts: day shift engaged in hewing the ore or coal; night shift engaged in rock cutting, in making tunnels or galleries, in breaking the ground, and in coggine, etc.; the shift for repair work entrusted with repairs, woodwork, etc.

The galleries are provided with wooden supports in the form of a trapeze, whilst the principal galleries, stables, pump rooms, machine rooms, etc., are lined with masonry and vaulted. Hewing is effected by hand (with pick and shovel in soft ground, with pick, crowbar and wedges driven in by a small hammer, etc., in hard rock) by a worker who is in a standing, kneeling or lying position according to the thickness of the seam; by machines (drilling machines, hewing machines, etc., worked by air or electricity, etc.) and by aid of explosives.

The ore thus obtained is transported to the centre of the mine, that is, from the working face to the entrance of the extraction shaft.

Transport is effected by means of baskets dragged along the ground, by barrels or skips on rails, pushed or drawn by hand, often united by a framework, and drawn by cables or chains by means of a stationary motor. Traction may also be effected by animals (ponies), or again the extraction of one or more of the coal may be effected by means of winches which raise the buckets, or more frequently, by a cage with one or several compartments moving up and down the shaft along posts fixed to the sides and suspended by cable from the extraction machinery. The full skips are placed in the cage which also serves for the transport of workers.

In other mines special working conditions allow of the ore or the coal being shovelled into inclined chutes or into
automatic buckets which descend on an inclined plane (dillies), the weight of the descending bucket causing the empty bucket to rise in the opposite direction.

The introduction of mechanical methods in mining is acquiring more and more extensive application; automatic loading of skips which pour the ore or the coal automatically into reservoirs; sorting of coal on a travelling band; automatic washing or dry cleaning; electric traction; transport of workers in small cars, etc., down to coal getting by means of tools worked by electricity, or compressed air.

Special services are entrusted with the removal of water from the workings, airing, ventilation and lighting, etc.

The removal of water from the workings is effected by means of pumps at the surface and sump pumps at the bottom of the mine. The technical service sees to the maintenance and proper working of the water mains, reservoirs, etc.

The day shift includes the services in charge of the shafts and accessory services such as that of the power factory, that of the lamp department (maintenance and safety of lamps, etc.), the handling and preparation of coal (crushing in mechanical crushers, riddling, sorting, and separation of dust which is utilised in the briquette factory, washing in order to free the coal from soil, etc., the installation and maintenance of railways leading to the shafts; at times the working of coke furnaces, the manufacture of briquettes, etc.)

Waste matter is thrown on to a dump ("terril").

Ventilation

As regards ventilation, it is necessary to distinguish between metal mines and coal mines. The latter are more dangerous, the presence of fire damp, carbon monoxide, sulphured hydrogen, etc., demanding the provision of mechanical ventilation. Metal mines, on the contrary, only possess natural ventilation, artificial ventilation being exceptional.

Artificial ventilation has for its object to furnish the mine galleries with a large quantity of air to attenuate or suppress the toxic or harmful action of gases.

Formerly, technical efforts were limited to a flame lit in the upper part of a chimney, which thus acted as a means of ventilation similar to the system currently adopted in buildings. This method is, however, defective, costly and even dangerous, since it involves risk of explosion by backfiring. At the present time, technical efforts in the field of ventilation consist in the provision of powerful exhaust ventilators and compressors.

In certain mines other than coal mines the high temperature in excess of the outside temperature generally suffices in ensuring air currents. There are, however, metal mines in which the installation of artificial ventilation is indispensable; with a view to combating other causes of ill-health such as dust, toxic fumes liberated during explosions or by the oxidation of certain ores, e.g. pyrites.

Whether the ventilation is mechanical or not, the principle of air circulation always remains the same. There are, as a rule, two chimneys, one of which serves for the entry of fresh air and the other for the removal of vitiated air. This circulation is so arranged that no short circuit can occur, the air being made to follow a well-determined route. This objective is obtained by means of partitions or doors which send the air current in the required direction. A system of ventilation is sometimes shared by two neighbouring mines, the one serving for the entry and the other for the exit of the air.

Ventilation at the working face requires special consideration since it is directly connected with the method of work engaged in. In certain headings without issue which are veritable pockets, work with compressed air tools, on the one hand, and the difficulty of furnishing good ventilation on the other make it imperative that a good system of ventilation by the supply of compressed air should provide the worker with satisfactory working conditions.

Harrington has demonstrated the advantage of a system of ventilation in which the supply and distribution of fresh air is effected by means of flexible hose pipes which are less costly, lighter and easier of manipulation than rigid metallic pipes, though, however, less resistant to wear and to causes of deterioration.

Air in Mines

Poisonous Gases

The air furnished should be pure, invigorating and cool. The oxygen content should never fall below the normal (about 20 per cent.) since man is unable to work at an oxygen content inferior to this figure without certain respiratory constriction. If the oxygen rate descends to 14 per cent. men become dizzy, suffer from rapid heart action, buzzing in the ears and sometimes headaches. Very few men escape these symptoms when the percentage of oxygen falls to 10 or less.

In mining when workers are exposed to oxygen in excess of the normal con-
centrations (compressed air work, use of self-contained oxygen breathing apparatus) signs of irritation of the lungs are observed. Leonard Hill, however, showed that these effects only occur after 48 hours of continuous exposure to an atmosphere containing over 80 per cent. of oxygen. Leonard Hill likewise pointed out that mules exposed to an oxygen concentration of 60 per cent. for over a year in the Hudson tunnels remained in perfect health. Henry Briggs, after extensive investigation, states that men not physically fit find bodily work easier when they breathe oxygenated air than when they breathe normal air, but no such difference exists in the case of fit men. Dr. Briggs found, however, that when overworking even the fittest of men derived benefit from oxygen-enriched air. From observance of men and animals, investigators of the United States Bureau of Mines found no ill-effects from, or objections to, breathing of almost pure oxygen at normal pressures and are of opinion that there is a potential if not an actual benefit to be derived from breathing oxygen where physical exertion is excessive.

If the nitrogen of the air is increased, no effects ensue other than those due to the dilution of oxygen, the results of which have just been referred to.

"Fire damp" ("grisou") constitutes the principal risk in mines since it gives rise to explosions and catastrophes so extensive as to cause consternation throughout the entire world. Generally, the limits likely to give rise to explosion lie between 5 and 13 per cent. Being lighter than air, this gas accumulates in the lower part of the tunnels or galleries, in pockets and in workplaces without issue, and constitutes at times a danger by reduction of the oxygen content rather than by the percentage which it attains in the air. For the workers its presence is heralded by a sort of cap which appears above the flame of the lamp. This sign is positive with a content up to 1 per cent., but where the wick is turned downwards and where a hydrogen flame is used (Clowes' lamp) it is positive even at a content of 0.2 per cent.

Another apparatus for detecting fire damp is the self-acting gas trap of Desmond with inverted flasks. The flasks are placed in a basin of water where the water is run off by means of an orifice with a thin wall. These flasks have a double closing device consisting firstly of a ground glass stopper and secondly of an indiarubber flap valve introduced into the flask and which, when the latter is empty, constitutes a hydraulic joint isolating the air in the flask from the outside air. The slow emptying of the water basin causes the air to enter the flask by means of successive bubbling whilst the water leaves it at the same time drop by drop. The means of guaranteeing the airtightness of the apparatus are extremely good (see below, "Lighting"). Ignition of fire damp may also be caused by discharge of sparks. Possibility of ignition due to electricity depends on several factors: kind of metal which constitutes the terminals between which the sparking discharge occurs; rapidity of breaking of the circuit; surface of the contact at the moment of circuit breaking; induction of the unit; voltage induced; nature of the current, etc. (Wheeler).

Methane is also an important element of fire damp the presence of which may cause serious consequences either in coal mines or in metal mines. Though the gas has no physiological effect upon man, it may accumulate to such proportions as to constitute an explosive mixture with the oxygen of the air. Further, it may dilute the oxygen of the air to such an extent as to produce the effects of oxygen deficiency already referred to.

Sulphur dioxide usually comes from the decomposition of sulphide minerals or from the burning of explosives which contain sulphur. There is occasionally sufficient concentration in the mine atmosphere to constitute danger. It is easily recognised by its characteristic odour.

Hydrogen sulphide (stink damp) may be found in mine air but usually only in very small quantities. It has an extremely repulsive odour in very low concentration which may serve as a warning signal. It may be produced in mines of ore with a high sulphide content by some types of decomposition of such ores and also from the use of certain types of explosives. It has been found, though rarely, issuing from feeders or blowers in coal mines.

Carbon dioxide, traces of which, at least, are always present in the atmosphere, has long been used as a measure for the purity of air, though its importance in this connection has probably been over-emphasised. Nevertheless, in mines it sometimes occurs in sufficient quantities to cause symptoms in the men, or even unconsciousness and death. It forms an important constituent of "black damp" when all or part of the oxygen of the air is replaced by combustion or
oxidation of the iron pyrites present in the coal:

\[
4 \text{FeS}_2 + 15 \text{O}_2 + 8 \text{CaCO}_3 = 8 \text{CO}_2 + \text{CaS}_2 \text{O}_4 + 2 \text{Fe}_2 \text{O}_3
\]

Where the oxygen is displaced the “black damp” consists essentially of nitrogen with 5-15 per cent. of carbon dioxide. It is sometimes mixed with fire damp. Its presence constitutes a normal accident in coal mines, especially in old, badly ventilated mines.

“Black damp” is recognised by miners by a darkening of the flame of the lamp, without, however, the cap over the flame characteristic of fire damp. When the content of this gas is high the lamp may even be extinguished, and when it exceeds certain limits it causes asphyxia. The English Mines Act (1911) demands that ventilation should not cause darkening of the flame or laboured breathing. Analysis of the air should show an oxygen content not inferior to 19 per cent. and a carbon dioxide content of 14.

Carbon monoxide causes a great many deaths amongst miners. This gas without odour, colour or taste, the effects of which remain unnoticed by the victim until it is too late, is the principal element in the so-called “after damp” or “white damp”. It is present in the air of the galleries subsequent to explosions, being a result of spontaneous oxidation or combustion of coal. In the gold mines in South Africa the percentage of carbon monoxide in the air after the explosions have taken place may not exceed 1 per 10,000 and should this occur work has to be suspended. Hoover (1921) has proposed a portable apparatus capable of detecting up to 0.005 per cent. of carbon monoxide in mines. This apparatus consists of a special substance: “holamite”, sulphuric acid, pentoxide of iodine and pumice stone. The reaction is chromatic (see also article “Carbon Monoxide”).

Atkinson recalls the composition of gas known under the name of “bottom gas” (gas du fond), a mixture of carbon dioxide, methane, carbon monoxide, nitrogen and hydrogen, which has been well described by Robertson. This heavy gas is met with in certain mines in New South Wales, where it lies on the ground in layers like a liquid, but which can, however, be rapidly dispersed by air currents and ventilation.

Dust

The presence of dust in mines constitutes an important risk for the health of workers. It often happens that workers become the victims of serious poisoning when mining ores of lead, carbonate or oxide, whereas lead poisoning is rare among men mining only galena (lead sulphide). Another example is the mining and smelting of mercury, where the danger has long been recognised. When the ore contains free mercury or the more soluble salts and when the workings are underground and poorly ventilated, some cases of poisoning occur, but the number is far greater amongst employees in reduction plants.

Poisonous dusts are found seldom, if ever, in coal mines.

The enquiries effected at Broken Hill (1921-1922) have provided the following figures in relation to the composition of the ore mined: lead, 11.27 to 16.18 per cent.; zinc, 7.84 to 15.99; silica, 36.08 to 60.50. The latter constitutes about three-quarters of the total composition of the ores. The insoluble part of this fraction is composed of silica and manganese dioxide for over 80 per cent.

The chemical analysis of lungs made during autopsy indicates the presence of lead, zinc, manganese and silica after a period of work in the mines of about ten years.

The proportion of manganese (0.0038 to 0.00033) in the lungs analysed was 90 times greater than that in a healthy lung. The proportion of lead varied from 0.0007 to 0.0001. A single analysis did not reveal traces of lead. The case in question was that of a miner who for twelve years past had not worked underground. The percentage of zinc was 0.0011 to 0.00008 as against 0.00012 in the normal lung. The quantity of silica reached the figure of 0.296, or five times that agreed as the average for purposes of control.

While in general not much manganese is found in the lungs of workers having worked for a period under ten years, there does not always, however, exist any apparent quantitative relation between the period of work in the mines and the quantity of dust accumulated. Thus in one instance the pulmonary tissue of a man who had worked during forty years in mines contained more dust than that of an individual who had only worked for a period of ten years, while on the other hand the pulmonary tissue of workers, having worked thirty-six years or longer contained less dust than the lungs of a worker with a much shorter period of work.

The operations in which most dust is given off in mines are blasting, drilling, transport and crushing of the ore.
During blasting conditions are extremely bad, the unhealthiness of the surrounding atmosphere being at such times very much greater than under any other conditions.

Drilling is done by hand or with the aid of machines. The first method causes greater liberation of dust than in the case of mechanical drilling. Under certain circumstances (for instance where the hole is being bored downwards), the hole may be dammed as soon as the aperture bored is large enough to contain water. In this manner dust cannot accumulate to a dangerous degree. But even with great care it has been found that a quantity of dust reaching 200 to 300 million molecules per cubic metre is produced by mechanical and compressed air methods.

According to Harrington (1925) dry-drilling machines liberate more dust when the motive power is electricity than when they are worked by compressed air.

It is extremely difficult to determine a limit involving a risk to health, or, in other words, to fix the safety limit for dust in the air of mines. Thus, for instance, in the South African mines the maximum allowed is 5 mg. (3.99 million molecules of dust) per cubic metre, but the most recent analyses have only revealed 1.5 mg. No American mine shows such a low figure: in 1915 research effected by Higgins and Lanza led to the fixing of a minimum value of 10 mg. per cubic metre. In dry metal mines this figure reaches 29 mg. and extensively 50 mg. In the case of dry drilling there has been met with 7,000 mg. of siliceous dust with an average of 150 to 250 mg. per cubic foot at a temperature of about 16° C., whilst in wet drilling the dust rate was only 5 to 20 mg. per cubic metre. The average reported per cubic metre in the Transvaal mines were as follows: 4.9 mg. in 1921, 1.6 mg. in 1922, and 1.3 mg. in 1923. Experience, particularly in South Africa, justifies the conclusion that the problem must be regarded from a different angle than formerly. It is sufficient, for instance, that a molecule of dust of 100 microns in diameter may have the same weight as 250,000,000 molecules of 2 microns. Consequently, 200 to 300 million molecules of very fine dust (2 microns) are necessary to give a milligram of dust, and extremely delicate methods are required for estimation of these infinitesimal quantities of dust. In the article "Dusts, Fumes and Smoke" the best methods of attaining this object are described. It is sufficient to state here that accurate estimation can only be made by use of extremely minute analyses. In coal mines, for instance, the weight of dust is not so high as in the figures indicated above, yet the number of molecules is, on the other hand, much higher.

Collis has demonstrated in a very thorough study (see article "Tuberculosis and Silicosis") the injuries caused by siliceous dusts frequently met with amongst miners in Australia, New Zealand and South Africa, in the silver and lead mines of Australia, etc., where the presence of siliceous dust gives rise to a high morbidity rate from respiratory disease. Silicosis is likewise met with in Great Britain in the tin mines of Cornwall, and in various mining districts in the United States (Missouri, Oklahoma, Kansas, Nevada, Idaho, Arizona and California), as well as amongst the granite workers of Vermont.

Much of the dust breathed, especially the larger particles, is deposited in the upper air passages of the respiratory system. Some of the fine dust (10 microns and under) reaches the pulmonary alveoli. According to the most recent investigations made by Mavrogordato (1922-1926), penetration of dust into the lungs causes the formation of a large number of cells ("dust cells"), which take up the particles of dust. Many of these dust-laden cells escape into the air passages and are coughed up and expectorated. Those which remain in the lungs become fixed and may be dangerous. The life of "dust cells" is normally brief. They may be carried off by the lymphatics, or may die and be digested or dissolved by the body fluids, leaving the dust previously ingested on the adjacent tissues, such dust possessing also a further means of escape similar to that of the dust cells. According to Mavrogordato: "It is the dust which cannot escape from the tissues which is a source of danger, and as long as elimination follows fairly closely upon the heels of ingestion not much harm is done. Coal seems to set up a sort of asthmatic 'catarrh' in which there is a steady exodus of particles from the lungs." Dust from hard rock containing no free silica but entirely composed of fine spicular hard minerals (89 per cent. feldspar, pyroxene and other dense minerals) remains in the lungs after inhalation. The dust particles appear, according to Mavrogordato, to have exerted some protective influence over the cells containing them, thus preventing the death and autolysis of the cells. The Miners' Pneumonitis Medical Bureau of South Africa has detected no fibrosis of a silicotic type amongst workers in the quarry producing this stone.
Among the miners of Broken Hill (Australia), where the stone contains an average of 12.23 per cent. of free silica and 45.57 per cent. of silicates, the men develop a fibrosis, but of a different type from that due to free silica. The lung tissue of men suffering from this type of silicosis is not so dense as that of men suffering from silicosis due to free silica. Furthermore, the X-ray findings are somewhat different, and the appearance is described as soft. Mavrogordato found that it took six months for the changes described to take place in animals. Gye, in experiments carried out in a somewhat different manner, states that the changes can be demonstrated in about a year. Seven and a half years is the average time of exposure of men in the gold mines of South Africa before simple silicosis can be diagnosed, and the shortest period of exposure is reported to be two and a half years. From the above it may be concluded that the length of exposure to silica dust necessary to cause silicosis varies with the conditions of exposure from several months to several years (Sayer) (see also article "Gold Mines").

The Anti-Dust Campaign in Mines

The anti-dust campaign is based on the following measures:
1. Prevention of formation of dust by wet mining methods (wet drilling; wetting of the sides, roof and bottom of the heading; wetting of the ore; use of sprays and water blasts to alloy the dust after blasting);
2. Good ventilation by mechanical means to replace dusty air with clean air;
3. Physical examination of all miners prior to employment and periodically thereafter to prohibit tubercular men from working underground, thus protecting them from the ill-effects of silica dust and protecting the other miners from the possibility of contracting tuberculosis, since men suffering from silicosis are very susceptible to this disease.

The Broken Hill authorities recommend that blasting should not be engaged in until the end of each shift; that a water jet intended to alloy the dust should be applied after blasting as well as thorough ventilation; that each time after blasting is effected drilling should not be engaged in except after a lapse of thirty minutes (after an hour only where the water jet has not been brought into play but merely ventilated; after two hours only where neither a water jet nor adequate ventilation has been applied); that all drilling should be effected subject to the precautions above referred to.

Adequate ventilation has greatly reduced the occurrence of asthma, as well as that of phthisis amongst coal miners.

It is, finally, necessary to emphasize the fact that wet methods alone are not sufficient for eliminating the dust from the atmosphere of the galleries, ventilation being perhaps the most important factor in this connection. Further, ventilation by means of compressed air alone is not sufficient to eliminate dust from the air in the heading during use of the drilling machine.

Subsequent to repeated research effected by the management in the South African mines, the conclusion has been reached that damp working is an excellent means of combating dust except during blasting. It must, however, be remembered that the air in the galleries often contains a very fine dust which is not susceptible of being detected by ordinary methods. It has also been shown that as far as conditions in South Africa are concerned the dust which has been damped by water spray contains less silica than dust which has not been subjected to this treatment.

These experiments and research prove that water, when used judiciously, forms as a rule the most satisfactory means of combating the dust hazard. According to experiments engaged in by Macarthur and Johnston the quantity of mineral dust per cubic metre was as follows (in milligrams):

<table>
<thead>
<tr>
<th>Time</th>
<th>Sept.-</th>
<th>April</th>
<th>Sept.-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>September 1911</td>
<td>1912 (with water spray)</td>
<td>1912 (with water spray)</td>
</tr>
<tr>
<td></td>
<td>(with out water spray)</td>
<td></td>
<td>(with water spray and supplementary humidification)</td>
</tr>
<tr>
<td>9 to 10 a.m.</td>
<td>230 mg.</td>
<td>32 mg.</td>
<td>3.3 mg.</td>
</tr>
<tr>
<td>11.30 a.m. to 12.30 p.m.</td>
<td>320 mg.</td>
<td>39 mg.</td>
<td>0.2 mg.</td>
</tr>
<tr>
<td>1 to 3 p.m.</td>
<td>280 mg.</td>
<td>39 mg.</td>
<td>3.1 mg.</td>
</tr>
<tr>
<td>4.15 to 5.15 p.m.</td>
<td>100 mg.</td>
<td>14 mg.</td>
<td>17.1 mg.</td>
</tr>
</tbody>
</table>

The methods of humidification being superior, the quantity of dust has now been reduced to 1.6 mg. per cubic metre (average of thirteen analyses) and even to 1.5.

The laying of dust by the use of special liquids containing colloids or by means of deliquescent or viscous substances has been considered, but it does not appear to have given better results than water. Belger, of Newcastle, has suggested a liquid called after him which contains calcium chloride and gum. Its use is, however, limited to ventilating chimneys where the air is below the point of saturation, the damp air having for its effect the liquefication and elimination of the mixture and the precipitate.

Haldane in 1930, however, reported that whilst methods of humidification had led to decreased risk from silicosis, they have
by no means eliminated that risk and, further, that they present a danger. Humidification favours the development of tuberculous infection and certainly that of ankylostomiasis, except where very strict methods of prevention, often difficult of realisation, are applied. The greatest obstacle to humidification resides in the fact that at great depths the bulb temperature becomes so high that efficiency is seriously interfered with. On this account Haldane has proposed the substitution for methods of humidification of the use of special dusts (shale, clay) projected into the atmosphere by special apparatus.

In the Rhine-Westphalia district, after having systematically applied during a quarter of a century the water-spray system for neutralising dust, there has been recently (1926) adopted a method known as aschiffisation, which assures greater safety, is more practical and less costly.

It is, however, advisable to wet the ore when it is attacked by the heavers and likewise the sides, the bottom and the hanging prior to blasting, as well as the ore prior to loading for transport.

Several types of masks have also been proposed as a protection against dust, but none of them corresponds to the requirements. When it is remembered that the most dangerous particles are between 1 and 2 microns, and that in order to accumulate dust for sampling purposes recourse must be had to sifted sugar, it is easy to understand how impossible it is to construct a mask which at the same time permits of respiration and filtration of dusty air. It has, since, been stated that the Technical Commission for Mines in the Don district (Russia) has adopted a type of mask invented by a worker as a protection against dust and which it is claimed has given very favourable results (1926).

**Dust Explosions**

The getting of coal and ore with a pick, drilling machines or explosives is always extremely dusty work. Further, the energetic ventilation required during this process constantly maintains in suspension a proportion of the dust which is raised by the going to and fro of the workers and of rolling stock.

It is now known that the production and violence of explosions is not to be attributed exclusively to fire damp, but that coal dust plays a very important role in regard thereto.

While a humidity rate of 30 and often of 15 per cent. renders coal dust inflammable (ignitees are usually without risk in this connection) variation in the content of volatile substances is of no practical importance. What is new to this is, that a coal under 11 per cent. is no longer dangerous, and dust explosions do not occur in anthracite mines. The concentration and state of subdivision of the dust have the same effect as the case of any other aerosol (see article "Dusts, Fumes and Smoke").

Explosion does not occur unless the oxygen content of the atmosphere is below 18 per cent. For this reason this limit must not be reduced where methane is present, even in feeble quantity. Ignition takes place at the moment when the explosive wave raises before it the amount of dust necessary for its propagation at a minimum rapidity of 27 km. per hour; when the aerosol contains explosive proportions or a detonating mixture of air-methane; or with the production of a high temperature requisite, for ignition.

The causes of ignition are due to imprudence on the part of the workers, defective lamps, electric sparks, dynamite fuses, etc.

The prevention of explosion and of its propagation involves precautions similar to those to be taken in a factory. For mines there have been proposed in addition: frequent cleaning of the galleries and the creation of dust-free zones to arrest the progress of the explosion (of slight effect); the reduction of the oxygen content of the air to 17 per cent., by application of flue gases (in the absence of methane only — which, however, has the disadvantage of rendering mining work less safe) and the creation of dust-free zones to arrest the propagation rather than to prevent the occurrence of explosions.

Dusting, which is superior to wet working, less costly, and has now withstood the test of long experience, deserves some mention.

Explosion can be prevented by injecting finely pulverised stone dust by means of a compressed-air machine at a rate of about one ton per hour and a rapidity of six metres per second. A cloud of dust hangs in the air for a long time (half an hour); its fine particles become intimately mixed with the coal dust, prevent any sudden rise in temperature and all explosion, and also favour precipitation of dust towards the ground.

This method is also useful after blasting, when the air is super-saturated with dust.

The use of dust in the galleries for the prevention of explosion has met with success in mines in the Dortmund district, but the miners have protested against the method since they see in it a health risk.

The experimental station of the U.S. Bureau of Mines at Pittsburg has studied the suitability of different kinds of dust for rock dusting in mines, and chemical and petrographical research has been engaged in, in relation to coal, quartz (the most dangerous dust from a health point of view), limestone, shale and kaolin dust. From these studies it has been concluded that limestone dust has no more
In eight Japanese mines the temperature varied between 25° and 31° C. and the relative humidity between 75° and 100° C. These unfavourable conditions were further aggravated by the presence of carbon-dioxide which was found to correspond to the following rates: 1 to 3 per cent.: 27 times; 5 to 10 per cent.: 5 times; 10 to 20 per cent., and over: 11 times.

Harrington and Sayers found on investigation of conditions in very deep metal mines in the United States stagnant air of 26° to 37.5° C. with the wet bulb thermometer. The slightest physical exercise caused the workers to suffer from increased blood pressure and fever (pulse 90 and over). Perspiration was very abundant, the miners complained of vertigo, weakness, incapacity for work, nausea and headache. These symptoms were less marked, but there was still increased blood pressure and fever when the thermometer registered 29.5°.

Without entering into details which have already received consideration in the article "Air: Heat and Humidity", it suffices to recall here that it has long been asserted that this vitiated air, especially in mines, reduces efficiency and constitutes a health hazard.

In order to determine adequate conditions of ventilation, air movement and humidity in the collieries, in other words conditions of comfort, it is the current practice at the present time to utilise the katathermometer, although certain authorities have raised objections to its use (see article "Air: Hot and Humid Atmospheres"). Haldane (1924) has studied the effect of humidity and high temperatures in certain metal mines in England. Neville Moss has carried out research both in the laboratory and in coal mines in England (1923), and Harrington and Sayers (1923) in the metal mines in the United States.

Cooling of the mine air by freezing apparatus has been considered by several mines and a plant has been installed by the St. John del Ray mine which cools 60,000 cubic feet of air from 76° F. and 80 per cent. relative humidity to 42° F. and 100 per cent. relative humidity.

A co-operative study of the effect of temperatures, humidities and air movement has been and is still being made under carefully controlled conditions by the Bureau of Mines, the American Society of Ventilating and Heating Engineers, and the United States Public Health Service, and has led to the following conclusions. The body is unable, even at rest, to compensate for saturated atmospheric conditions exceeding 90° F. when there is no air movement; remaining at rest in such an atmosphere in time causes an increase in the body temperature, an increase in the pulse rate and profuse sweating; the extent of discomfort is apparently determined by the pulse rate; subjects complain of being very uncomfortable when the pulse rate exceeds 135 pulsations per minute; symptoms become distressing when the pulse exceeds 160 per minute; symptoms experienced by exposure to higher temperature include restlessness, irritability, headache, itching of the skin and scalp, palpitation, weakness and subsequent fatigue (and over).

A given temperature and humidity rate may involve effects of exposure...
varying with the dry bulb and wet bulb readings and the air movement, varying in other words with the cooling power of the air. Air movement exercises a favourable effect on the body when the temperature is below 98.6° F.; in temperatures higher than that of the body, air movement increases discomfort. There is no advantage to be gained by imparting to the air movement a rapidity exceeding 500 linear feet per minute as far as the cooling effect on the body is concerned.

The zone of comfort is approximately between 62° and 69° F. In this zone the relative effects of the dry bulb and wet bulb temperatures seem to be approximately equal.

The effects of high temperatures may be lessened by: air movement (ventilation) when the temperature is below 98° F.; ventilation to replace warm air by cool air; cooling mine air by freezing apparatus.

The Central Hygiene Committee for Mines and the Coal Miners’ Committee in France have judged it expedient to fix at 6 metres the rapidity of air for ventilation purposes, which figure, except in very exceptional cases, is sufficient for assuring adequate ventilation provided that the air distribution is adequately assured and thoroughly controlled. When the temperature falls below 24° C. there should be a minimum ventilation of 1 metre per second.

The importance of good ventilation in mines from the point of view of efficiency has been brought to notice by the Committee appointed in 1920 to study working conditions in the Rand mines. Orenstein and Ireland, who published the report, have asserted that the working capacity of native miners commences to decrease as soon as the readings of the dry katathermometer fall below 6, and those of the wet katathermometer below 16. When the dry bulb registers 1.5 only and the wet bulb 5, working capacity is said to fall to 55 per cent. of its maximum. Such limits are, however, but rarely met with. Insufficient ventilation in mines is said to be the cause of a total loss of working capacity valued at 21 per cent. Heat and stagnation of the air which prevail in certain parts of the mine are also responsible for cases of pneumonia, which attain annually a rate of 2.65 per thousand for native miners and cause 23 per cent. of the deaths. In fact a miner bathed in perspiration has often to pass from a hot and humid atmosphere, where the dry bulb thermometer registers 2 or 3 and the wet bulb at least 9, to the outside where readings are 10 to 13 for the dry bulb thermometer and 27 to 30 for the wet bulb. Or again, he is obliged to pass through different parts of the mine where there are violent draughts (7 to 9 dry bulb). The miner under these conditions is naturally subject to shivering and exposed to grave risk from diseases caused by chill.

Transition of workers from the hot and damp mines to the outside air causes, according to different climates, lesions of the different organs, which are at times serious, and particularly of the respiratory system. Thus, for example, Murphy insists that the mortality from bronchitis amongst workers in English mining districts is higher than that for women in the same districts. In fact, for every thousand women who died of bronchitis in England and Wales there have been found, for the period 1920-1924, the following figures:

<table>
<thead>
<tr>
<th>Districts</th>
<th>Annual average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wales</td>
<td>1,982</td>
</tr>
<tr>
<td>Cardiff</td>
<td>1,175</td>
</tr>
<tr>
<td>Swansea</td>
<td>1,169</td>
</tr>
<tr>
<td>Urban districts in the Southern counties</td>
<td>819</td>
</tr>
</tbody>
</table>

On the other hand, figures for men in mining districts are very much higher:

<table>
<thead>
<tr>
<th>Districts</th>
<th>Average Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhondda district</td>
<td>1,554</td>
</tr>
<tr>
<td>Pontypriidd</td>
<td>1,357</td>
</tr>
<tr>
<td>Ogmore and Garw</td>
<td>1,633</td>
</tr>
<tr>
<td>Nantyglo and Blaina</td>
<td>1,355</td>
</tr>
<tr>
<td>Ebbow Vale</td>
<td>1,576</td>
</tr>
</tbody>
</table>

The influence of atmospheric conditions on the working capacity of miners has been studied in Great Britain by Vernon, Bedford and Warner (1927). They have estimated this capacity in relation to rest periods during work and to the time taken to fill skips of about 500 kilos, the enquiry covering 137 men observed during a period of 96 minutes each. When the wet bulb thermometer registered 19-14 a rest of 7 minutes per hour was enforced; when it marked 7-5 a rest period of 22 minutes. In the first case the filling of the skips demanded 8 minutes, in the second 9.6. It has been calculated that with the most disadvantageous atmospheric conditions efficiency was 41 per cent. lower than with the most favourable.

Atmospheric conditions similarly exert an effect on the incidence of accidents as well as on their severity. In fact in three mine galleries, where there has been reported a serious accident rate of 3.2 with a temperature of 13.7, the wet bulb, 4.8 with a temperature of 11.3 and 4.9 with a temperature of 10.2, Acci-
dent frequency was influenced in like manner. The authorities in question are of opinion that the worse the atmospheric conditions are the greater is the risk to the workers' health.

The authorities in question are of opinion that the worse the atmospheric conditions are the greater is the risk to the workers' health.

Lighting in mines is effected by means of candles, acetylene lamps, or safety lamps lit by oil or spirit, or finally by means of electric safety lamps (portable or otherwise).

**Candle light.** — The luminosity of candles used by miners varies considerably, according to the quality of the tallow of which they are made, the variation extending from 0.6 to 1.10 Heßner lux. The recognised average luminosity is 0.80 lux. The light provided by candles does not remain constant since the yellowish flame is affected by draughts in the mines and by damp atmosphere (in which its brightness is reduced), in short, it is given to flickering even in a stationary atmosphere.

From the point of view of avoidance of eye-strain, two cases may be considered:

(a) the worker carries a candle fixed in an earthenware candlestick placed above the peak of his leather cap;

(b) the worker places the candle opposite him on a wooden ledge, or against the wall or on the ground.

The latter case is obviously unsatisfactory since the glare from the flame is directed into the worker's eyes, whilst with the candle fixed in the cap, the peak of which forms a screen, the worker is provided with better protection.

**Acetylene lamps.** — These lamps fulfill very adequately the requirements of hygiene in mines where it is permissible to utilise a light source with an open flame. They must, however, be screened like the others to prevent their constituting a possible cause of injury to the eyes (see article "Miners' (Coal Miners') Nystagmus").

**Oil safety lamps.** — The original type of these lamps was invented in 1815 by Davy, and with successive improvements in form represented by the Cluny lamp, Boty lamp, Fumat lamp, and the foreman's lamp, the use of these lamps gradually became general in mines.

From the physiological point of view the oil safety lamp (Musseler type) presents the following characteristics: its average luminous capacity is 0.55 lux; at the entrance to the working post its luminous capacity may reach 0.66 lux, but the brilliance of the flame decreases rapidly and at the end of three or four hours its lighting capacity falls to half its original value, and even below that.

The miner has no means of regulating the flame, for it is impossible for him to open the lamp to trim the wick. Further, these lamps on account of the

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1 According to the report of Dr. Stassen (Liège) on miners' nystagmus (see article "Miners' (Coal Miners') Nystagmus").
use of heavy oil tend to become choked with dirt which interferes with the flow of gas. It should be added further that these lamps smoke, the glass shade thus becoming covered with dust. As the day advances the lighting conditions become progressively worse for the miner, this state of matters being the more detrimental as it exerts its effect on visual organs which are already fatigued.

The flame of the oil lamps presents a further inconvenience due to flickering, this disadvantage being increased since the miner in order to see better is obliged to bring the lamp very near to his eyes. The light produced is reddish-yellow. Oil lamps used in certain mines (Belgium, for instance) are not provided with reflectors with the result that the workers' eyes receive no protection from the glare of the flame.

**Spirit safety lamps.** — The most currently used type of this kind is the Wolff lamp, fed from beneath. The average luminous capacity of these lamps is 1.20 lux, or about twice that of oil safety lamps. Further, they present the advantage of burning comparatively steadily, since with the use of spirit the wicks smoke but slightly and the supply is always regular as long as there remains an adequate amount of spirit in the reservoir.

At the end of an eight-hour working day the luminous capacity of the Wolff is still about 0.88 lux. With the spirit safety lamp the miner can regulate the flame thanks to a screw which turns the wick; he can thus increase the luminous capacity. The spirit lamp is in addition provided with an interior lighter.

The flame of these lamps is yellowish and is unfortunately not absolutely steady, since it also is liable to be affected by draughts in the mines galleries.

In the great majority of cases the lamps in question are not provided with reflectors. Consequently the workers' eyes are not protected against the glare of the flame. Finally, these lamps are not entirely free from the objections made against oil lamps, namely that the glass shade becomes dusty in the course of work involving a certain diminution of the luminous capacity of the lamp. On this account the miner, especially the hewer, is obliged in order to see better to ap-
Electric safety lamps (with storage batteries). — Portable electric lamps are practical for use at the bottom of a mine. They are already used in all coal mines.

From the physiological point of view, however, electric lamps possess considerable advantages over other types. Their luminous capacity is 1.60 to 2.20 lux, and it remains fairly constant during the whole shift.

Their light is steady and clear and when the glare of the incandescent filament falls on the workers' eyes the discomfort produced is not so marked as in the case of glare from oil or spirit lamps. The objection is, however, raised that electric lamps emit more blue rays and even ultra-violet rays than other safety lamps, which fact obviously constitutes a fairly serious disadvantage as regards eyesight. This objection could be met with by the use of opaque glass bulbs.

Reference has already been made in the article "Miners' (Coal Miners') Nystagmus" to the harmful effects of unduly weak lighting and the means proposed to prevent injury caused thereby. It has been noted that in certain countries (United States, for instance) nystagmus does not occur more often amongst miners than amongst the general population.

This is probably due to the fact that in the majority of mines acetylene lamps are used, or that the lamp used is fixed to the miner's cap directing the light on to the work and not causing any ocular discomfort.

This problem, which is of primary interest for other countries (Great Britain, for instance), has been the subject of enquiries and investigations dealt with at length in the article "Miners' (Coal Miners') Nystagmus". Recently (1926) the Industrial Fatigue Research Board has directed its attention to the means to be adopted for reducing the glare from unprotected light sources. It is evident that in dense obscurity a light source even with low luminosity and little glare may be the cause of ocular injury. It is urgent that miners should be convinced of the necessity for using lamps which are heavier than those at present in use but which will provide more abundant and diffuse light. It is to be hoped, moreover, that eventually technical improvements will make it possible to attain this object without increasing the weight of the lamps.

Finally, the management should pay strict attention to the maintenance and charging of the storage batteries, the choice of a good lamp and especially of a good bulb. It is also possible that the colour of light emitted by the lamp may play an important role.

In 1908 Snell drew attention to the importance of selection of workers to be entrusted with the work of detecting toxic gas in the mine collieries. It is notorious that this extremely delicate task is often entrusted to old miners, sometimes victims of nystagmus, and that detection of firedamp is effected by modification of the form of the flame of safety lamps, a form which is characteristic according to the quantity of firedamp present in the atmosphere. Snell, however, found no difficulty in asserting that the nystagmus lesion in a worker and the oscillating movement of the lamp constitute obstacles which hinder him from recognising the slightest modification of the flame, with the result that the alarm cannot be given even until it is too late, that is to say when the quantity of firedamp is already such that it is no longer possible to obviate the risk.

At present electric lamps are coming more and more into use and replacing oil lamps. It is therefore necessary that these new lamps should also replace the function of the former lamps as a danger signal. With this in view technical efforts made to construct simple electric lamps serving likewise for detection of firedamp have recently succeeded (1926) in the construction of a type of lamp containing a small receptacle for oil below the electric lamp. A switch enables the electric lamp to be extinguished and the oil lamp to be lit by means of a platinum wire, the oil lamp being so regulated that a percept of detection of the gas at a content varying between 1½ to 5 per cent.

Another type of lamp which detects the existence of firedamp by sound is constructed on the principle known as "chemical harmonica". It does not provide an absolute guarantee in its working unless the flame is produced in accordance with the principle of the Bunsen burner. The lamp commences to produce sound with a methane content of 2 per cent. As the content increases the sound becomes more piercing and at the same time the flame becomes brighter. It is extinguished when the methane reaches 5 to 6 per cent.

The introduction of electric lamps will lead to the suppression of another source of danger for workers entrusted with the maintenance of lamps, and
for those engaged in factories making paraffin strips treated with phosphorus paste for lighting miners' lamps. These strips consist of a band of metal 2 mm. broad and cut to a length of 45 cm. This band is covered at intervals by a layer of paste with a basis of white phosphorus, known as "Caps", having a width of about 3 mm. The space between two applications of this paste measures 5 mm. and each band holds 42 applications. It is introduced into the lamp by the head lamp man when the oil or spirit lamp is extinguished. The worker by means of an external device turns the paraffin strip with the result that the paste coming into friction with a pointed surface ignites the extinguished wick. It would appear to be technically impossible to replace white phosphorus by red phosphorus since the more violent friction necessitated might present a cause of danger (sparking discharge across the metal strip). Cases of phosphorus poisoning have been notified amongst workers engaged in making these strips, but cases amongst miners or workers in the lamp department of mines have not so far been reported.

English legislation contains certain provisions with regard to safety lamps (Order No. 1055 of 30 June 1926), whilst in France an Order issued in 1925 (9 October) deals with the types of electric lamps permitted for use in lighting mines.

**EXPLOSIVES — ODOURS**

The use of explosives in mines merits quite special attention, not only because they may give rise to accidents, but particularly because certain explosives are more apt than others to liberate toxic gases and fumes. *Liquid air* is also largely used (see article "Air, Liquid").

In the United States a study of explosives has been effected by the Bureau of Mines, which has designated as "permissible" certain types fulfilling the requirements of safety demanded for work in mine galleries.

In the composition of gases evolved during the outbreak of fire, the content in combustible gases (carbon monoxide, methane, hydrogen) is low. At the outbreak of fire, carbon monoxide, hydrogen and hydro-carbides are given off, later large quantities of carbon dioxide and a little oxygen, and finally, combustible gases and large quantities of carbon monoxide. Towards the outbreak of fire the gases formed are extremely rich in explosive gas (20 per cent.).

The use of explosives, the slow combustion of veins of coal, etc., liberate large quantities of carbon monoxide. Nitro-glycerine, in the form of dynamite produces a gaseous mixture containing up to 35.9 per cent. of carbon monoxide (Levin). Repeated explosions, especially in narrow and badly ventilated mine galleries or tunnels, and dust explosions constitute the most frequent cause of evolution of carbon monoxide.

During outbreaks of fire, extinguishers are often used. These should always comply with certain safety principles. In this connection the following recommendations have been drawn up: the use of extinguishers shall be prohibited in all places where there is close and vitiated air, and in paint shops (machines running on oil) and in galleries through which passes air that has already ventilated other galleries or where the atmosphere presents a high humidity rate. Their use may be permitted in well-ventilated galleries where the humidity rate is low, and where air is provided in sufficient quantity to dilute the gases given off. Extinguishers, however, shall not be employed except when there is every guarantee that the air vitiated by the gases given off will not penetrate to places where workers are engaged. These precautions are all the more necessary since extinguishers containing carbon tetrachloride (see that article) may give rise to highly toxic products of decomposition.

Finally there should be mentioned the use of certain odours as alarm signals. Thus, for instance, the introduction of non-toxic odours into compressed air has demonstrated that human life can be saved by the adoption of this method and many disasters avoided. The method in question may also be adopted with a view to detecting escapes in the gas mains, steam piping, etc.

The most adequate measures possible should be taken with a view to the dispersion of smoke and fumes in order to reduce as far as possible all inconvenience in the neighbourhood and possible harm to vegetation. Several countries have issued legislative provisions relative to the prevention of danger due to electric short circuits in mines.

**GAS FROM MINE DUMPS**

'Dumps heaped around mines, and especially around coal mines, often contain dangerous gas due to slow combustion fostered by humidity from rain, and to heat generated by the pressure
of the superimposed mass of material. Since the dump always contains combustible substances — and notably coal debris — mixed with all kinds of impurities, the gases given off comprise hydro-carbides, sulphur and carbon dioxide, carbon monoxide, etc., gases which on coming into contact with the atmosphere surrounding the dump may be productive of explosive mixtures.

When the prevailing wind facilitates penetration of air into the interstices of the material composing the dump, the oxygen thus introduced fosters combustion and likewise contributes to the liberation of toxic gases.

A distinction has been made between those dumps which have not been moved and which are considered dangerous and others which have been removed to another place and which in the course of this operation have been thus ventilated, subsequent to combustion. By reason of this fact the latter are considered less dangerous though they may have given rise to serious explosions in the course of removal to another site.

It is also considered that very old dumps represent less danger, since sufficient time has elapsed to allow of entire combustion taking place and of all the gas being liberated. Experience has, on the other hand, shown that such dumps are in reality excessively dangerous as, for instance, in the case of a dump at the Hörder coal mines in Schleswig, where during work an explosion occurred with eleven victims out of 40 workers engaged (Philipp).

The gases liberated from dumps may also set up poisoning.

Finally during the work of removing the dumps to another site workers are exposed to risk from falling material which may cause contusions, fractures, and sores, where there is ignition of gases, also burns. The importance of measures of individual protection is confirmed by the following fact. A case occurred in which a worker by reason of adequate protection in the matter of thick clothing and high boots, suffered only very slightly from burns on the exposed parts of his body during the work in question.

Amongst the measures recommended for the prevention of accidents due to explosion, poisoning, and burning, the following are particularly worthy of attention: strict supervision of work at dumps; wise and frequent instructions for the workers relative to the dangers involved in this work; prohibition of working in a dump or in a tunnel traversing it without provision of a safety rope. The latter should be fixed in such a manner as to permit of the worker detaching it if necessary; recourse should be had to the use of danger signals. Workers should be informed before commencing work of the situation of refuges where they can take shelter in case of an explosion or waves of gas. In indicating such places of refuge, account should be taken of the direction of the wind. Boots and heavy working clothing should be provided as protection against fire.

For “First Aid”, see that article.

**Personal Hygiene**

**Personal hygiene** in the mining industry is of capital importance. It is primarily necessary to furnish workers with working clothes, caps and where necessary suitable boots (in very damp mines, for instance).

It is also indispensable that workers are provided with drinking water complying with the conditions laid down by the public health authorities. Drinking water used in mines may be contaminated at its source, during distribution, and even in the course of its use. Where it is not possible to have a supply of pure drinking water, recourse must be had to sterilisation by boiling or by treating it chemically with calcium hydrochloride, etc. Small filters such as household filters are of little value. They retain the solids, but do not remove disease germs. The best method for distribution of drinking water in mines is by bringing it in water mains directly from the source to the place of distribution.

If containers such as barrels or kegs are used for taking water underground, they should be maintained in a thoroughly clean condition and be subject to constant supervision with a view to avoiding contamination. Any ice used to cool water should be made from distilled water or from water the source of which has been approved by the public health authorities, unless where the ice and the water to be cooled are not brought into contact.

The use of common drinking cups should be prohibited, and sanitary drinking fountains installed in the mines (see article “Personal Hygiene”). Each worker should be provided with a drinking cup.

A study has been made in regard to the best type of drink for satisfying thirst, which will at the same time compensate the considerable loss sustained by the body during arduous work. Good results have been found to ensue from the use of salted water (potassium chloride 120 grm., sodium chlor-
Cloakrooms with facilities for changing clothes, lavatories, and especially douche baths, are absolutely necessary in mines in the interests of good personal hygiene. Provision should also be made for drying clothes in order to protect the workers from a frequent cause of rheumatic affections.

The installation of pit-head baths is now compulsory in Germany, and in general use in France and Belgium. In Britain their use has been unanimously recommended by the miners' committees; nevertheless, mine owners have opposed the installation of these being made compulsory as long as the miners are under no compulsion to make use of them. The British Miners' Federation made a similar declaration, but it did not propose the support of members. The Act of 1911 makes the installation of bath rooms compulsory provided two-thirds of the workers vote therefor. It also compels the workers to provide the half of the cost, the maximum contribution being limited to 3d. per week per worker. This rate being absolutely insufficient to cover the half of the expense, the regulation in question has remained in general a dead letter.

A type of installation used in England answers the following description: 50 bathrooms opening on to a central cloakroom where the workers' clothes are attached to endless chains reaching from the ceiling to the floor and furnished with hooks; a numbered chain closed by means of a padlock, of which he is given the key, is furnished to each miner; all the bathrooms are heated with hot and cold water; radiators are placed at the level of the flooring to permit of drying or airing clothes; and there is a special room for drying very wet clothes. The workers furnish their own soap and towels, and pay a weekly subscription of 6d. for cost of maintenance. It is calculated that in the establishment in question 60 to 70 per cent. of the 2,900 miners make use of the baths. 70 douche baths provide bathing facilities for 420 men per hour, 7 minutes being allotted to each man.

At the end of the week each worker takes home his working clothes to have them washed, and the bathing accommodation receives a thorough cleaning. The establishment is managed by a mixed committee consisting of employers and workers' representatives. The Miners' Federation, which favours the establishment of pit-head baths, is, however, of the opinion that the cost of their installation and maintenance should be entirely borne by the industry. The workers are, however, opposed to the creation of an establishment of this kind near the mines, and it is considered that active propaganda would be required in the district to convince the miners and their wives of the advantages to be gained from its installation.

Whilst the problem of providing privies is comparatively easy of solution outside the mine, it presents certain complications as regards conditions in the underground workings. Installations of this kind should be available for the workers fairly near to their working posts and so disposed as to avoid the possibility of their becoming sources of contamination in the mine.

Latrines should be situated near the principal ventilating shafts, and the walls and roof of these should be whitewashed. Under no circumstances should they be allowed to get into a filthy state. Tin pails should be so constructed that there is no possibility of disease propagation by flies, rats, mice, or by water. Everyday experience has shown that inadequate or badly regulated devices of this kind facilitate the development of intestinal infections, particularly typhoid, dysentery, ankylostomiasis and other parasitic infections; that a sewage system is not practicable in most mines; and that in consequence it is essential to enforce the use of airtight receptacles, access to which is impossible for animals. It is advisable that a disinfectant should be placed in each receptacle: caustic soda (at 10 per cent. recommended by Chapman, Australia); cresol and other similar disinfectants are also good.

Tin pails or latrines should be situated at convenient points. They should be well lit, and their surroundings maintained in a thorough state of cleanliness.

Movable tin pails or latrines (trucks) have been used in many mines with satisfactory results (United States). Whatever the type used, adequate and constant supervision is always required with a view to good maintenance. A man should be entrusted with this supervision, and should undertake it at regular intervals.

All mines should have convenient latrines in sufficient number and hygienically installed, but it is certain that they cannot be maintained in accordance with the best principles of hygiene unless the miners have been trained in habits of cleanliness.
Care should be taken not to contaminate river water or subterranean water, and to this effect adequate means of filtering and purifying waste water from the establishment should be assured.

MEDICAL CARE AND SOCIAL WELFARE

Medical care in mines is one of the most important factors in assuring the health of the staff and securing the best possible efficiency. It has for its object not only to organise and provide first aid in case of catastrophes, accidents, or illness, but also to organise and carry out medical examination and thereafter periodical medical examination of the miners. The campaign against ankylostomiasis constitutes, for instance, one of the triumphs of preventive medicine.

The advantages of the collaboration of a trained doctor in the management of a mine have been often proved by practical experience. The participation of a doctor in the campaign against industrial accidents and their consequences, against illness and invalidity (more particularly against disease connected with the exercise of the miner’s occupation), in the organisation of measures of hygiene to be adopted with a view to securing for the mining population a maximum of comfort, has now been recognised by the industry, which, in several mining centres in Belgium, Germany, Great Britain, etc., can boast welfare schemes and medical organisations (dispensaries, etc.) of far-reaching importance.

The data provided relative to the activity during 1905 of the dispensary “Espérance” at Montégnée (Liège) are interesting. This dispensary comprises a service dealing with medical examination on entrance, supervising the employment of tubercular subjects and those predisposed to tuberculosis, providing treatment for them, as likewise for throat, nose and ear cases. It collaborates in the application of regulations concerning health supervision of young persons issued in virtue of certain laws. It keeps a register containing a file for each worker, and interests itself in their vocational guidance. Another important service is that for first aid in case of accident and rescue work. Not less important is the service concerned with sickness: classifying, examining and passing on to the competent technical service unfavourable reports concerning chronic and occupational disease, and respiratory disease. A fourth service is concerned with industrial hygiene, and effects work of immense importance. It might even be designated “hygiene and public health service”. This service, in fact, deals not only with questions affecting the staff, but also with all sorts of problems affecting their families: workers’ dwellings, infant care, hostels for foreign workers, medical treatment for women, propaganda, etc.

If proof were required of the value of a social service of this kind, sufficient evidence thereof is furnished by figures provided by Stassen: the mortality per annum and per 1,000 workers has fallen from 1.8 in 1906-1909 to 0.9 in 1910-1914 and to 0.3 in 1919-1925, whilst in the neighbouring collieries, which had no service of this kind, there was in 1919-1925 1 death per 1,000 workers and per annum.

The average number of days of unemployment per 10,000 days of work was 38, whilst in the other collieries of the Liège basin it amounted to 105. Costs per head per annum are represented by 45 Belgian francs and in the other collieries by 92 Belgian francs.

Whilst in 1907 370 working days per annum were lost by each working miner on account of accidents, in 1920-1925 this figure had been reduced to 1, or in other words 4 days per worker per annum had been gained, working out to a total gain of 40,000 working days per annum which exceeded 1½ million francs. (In reality the workers realised a gain of about 800,000 francs taking an average daily wage of 20 francs, the company about 320,000 francs by reason of the fact that there was no legal obligation to pay half-time rates, whilst the company stood to gain a further 200,000 francs by reason of the extra working days, at the rate of about 5,000 francs for 1,000 days.)

The competent technical service undertakes the maintenance of respiratory apparatus and masks and all such apparatus as compressed-air devices, haulage apparatus, transport facilities, etc.

It is well known that infection of external lesions is particularly frequent amongst miners and is often the cause of long illnesses or even death, which in many instances can be avoided by adequate first-aid treatment provided by a trained staff (nurses), or, where there is a very large staff, by a permanent ambulance service including a surgeon or qualified doctor. The ambulance rooms are situated near the pit-head in a well-selected spot. It is often possible to reserve a room for this purpose in the building which contains the cloakrooms.
Safety and Welfare

The above measures, to give effective results, should be supplemented by rescue and safety services, generally run in connection with the fire brigade for the mine. It is especially the training for instruction and equipment of rescue workers should be provided with all requisite safety devices against fire and accident, and should have a special training ground. Training should be carried out in galleries corresponding as nearly as possible to the actual conditions in mines, in an atmosphere charged with steam, a temperature reaching 50° C., toxic fumes, etc. In Germany, for instance, a special gallery has been constructed for the study of reactions between explosives, fire damp and coal dust. Special lectures should be given with a view to instructing skilled miners in accident prevention, etc.

Measures of social welfare for miners are similar to those for workers in general: see articles on Social Welfare. Cheap workers' dwellings, gardens, hostels for single men, recreations, provision of food-stuffs at a reasonable rate, classes in domestic science, etc., all represent activities which the industry, the State, or both together have in some cases already engaged in or ought to engage in more generally in mining districts.

Legislation

It is difficult to summarise even briefly all legislative provisions in regard to the health and social welfare of miners issued in the various countries. In general, it may be stated that the mining industry has in most countries been made the object of special legislation, the application of which is under the authority of a special inspection service (Mines Department). However, certain measures which are strictly medical come within the control of the medical inspector (in Belgium, for instance). The introduction of safety lamps; protection of women and children, and, ultimately their exclusion from work underground; control of plans for mines, ventilation, especially with a view to avoidance of explosions; measures of safety; the use of explosives, the danger from dust and firedamp explosions; the length of the working shift; the installation of lavatories and douche baths; the application of water in certain processes of coal-getting (drilling, etc.); the notification and later compensation of certain diseases to which miners are liable; the wearing of masks and breathing apparatus; the organisation of rescue work in the case of accidents; testing of eyesight for certain categories of workers (* firemen*, etc.) — these all represent the principal and successful stages in the progress of legislation in regard to work in mines.

Amongst the States which possess a Mining Code and often a series of regulations dealing with the different matters above referred to, the following may be quoted:


**Measures of social welfare for miners** are similar to those for workers in general: see articles on Social Welfare. Cheap workers' dwellings, gardens, hostels for single men, recreations, provision of food-stuffs at a reasonable rate, classes in domestic science, etc., all represent activities which the industry, the State, or both together have in some cases already engaged in or ought to engage in more generally in mining districts.
underground work the following limits have been established: Nova Scotia, Portugal, Venezuela, 12 years; Germany, Italy (when the coal-getting is mechanical), 13 years; Australia (Western Australia (coal mines), New South Wales, Queensland), Austria, Belgium, Bulgaria, Canada (Saskatchewan), Ceylon, Great Britain, Hungary, India, Ireland, Italy (when the coal-getting is not mechanical), Japan, Yugoslavia, New Zealand, Tasmania (coal mines), 14 years; Canada (British Columbia (coal mines), Quebec), France, Poland, Sweden, 15 years; Australia (Western Australia) (metal mines), Canada (Alberta), Holland, Luxemburg, Norway, South Africa, Spain, Tasmania (metal mines), 16 years; Australia (Victoria), China, 17 years; Argentina, Australia (South Australia), Canada (Ontario), Chile, Peru, and Rumania, 18 years.

In the United States legislation is very complicated since it is different for each State. It may be said in a general way and as an instance of this that 23 States have fixed the age of 16 years as the minimum age for admission to mines and quarries, whilst in others this limit is subject to certain exceptions. In four States only, young persons under 16 years of age are admitted to work in mines.

Belgium issued in 1924 (17 October) an Order regulating the use of explosives in mines, and Great Britain Welfare Orders No. 790, dated 20 August 1927, 1929, and 1930, with the same object; China on coal No. 308, dated 5 May 1923, dealing with accident prevention, and another, No. 349, dated 12 May 1923, on work in mines; in Western Australia the Miners' Phthisis Act was amended in 1925 (31 December) (Regulation of 16 March 1927); and in the Gold Coast an Order on native labour in mines was issued on 2 October 1925; in New South Wales the Act of 1 March 1927 deals with compensation for pneumoconiosis and tuberculosis and the Union of South Africa issued on 27 July 1925 an Act No. 35, codifying and amending the Acts relative to miners' phthisis and on 8 March 1926 a Govt. Notice, No. 401. Examination with a view to the exclusion of any workers suffering from tuberculosis or other contagious diseases was enforced by Western Australia in 1926.

For further data relative to legislation see articles "Miners' (Coal Miners') Diseases," and "Miners' (Coal Miners') Nystagmus.

1 In certain countries women are also allowed to work in the mines, but it should be noted that arrangements for their progressive withdrawal from this work have now been under consideration for some time. Thus, for example, the average number of adult women engaged in the coal mines of Bengal was, in 1926, about 8,000 underground and 5,000 (in 1925) at the surface. In the provinces of Bihar and Orissa the number was respectively about 19,000 and 12,800. In the mines of the Central Provinces of India the number only reached 1,472 underground and 897 at the surface. An Indian Act (1929) prohibits women working in mines. Japan is also in course (1929) of eliminating underground work (mines) for women and young persons (under 16 years of age).

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Mirrors

The manufacture of mirrors consists of two phases: the preparation of the glass and the manufacture of the reflecting mirror.

So far as the preparation of the glass is concerned, it is necessary to begin with crude glass of special composition with an excess of silica. The glass must be perfectly transparent, without the presence of any colour, and as it is a little soft, it is necessary to give it a hardness of about 20° Reaumur, without passing through the formation of air bubbles, into the glass, which is well cleaned and dried, and is open to give a free passage to the air.

The glass is ready about twenty to thirty days later. It is then run into a drain running round the table. It is washed with distilled water, and the operation is repeated if it is desired to obtain a richer film. It is then slowly dried at a temperature of about 28° C.

The silver nitrate solution which is used is made alkaline by ammonia, which has the property of dissolving the silver oxide thus formed in an alkali medium. Use is made of the following as reducing agents: formaldehyde (Liebig), essence of cloves and thyme (Drayton), essence of camomile (Wagner), sugar of milk (Liebig), glucose, nitromannite, tartaric acid, etc.

In the process commonly used (that of Brossette) the deposit of silver is obtained by heating to 40° C. a solution of silver nitrate with tartaric acid and ammonia.

After drying, the layer of silver, the thickness of which is never more than 1/16,000 mm., is covered with a lacquer (gum lacquer, etc., dissolved in alcohol) and a layer of varnish (benzene, turpentine, linseed oil, resins, etc.).

To prevent blackening of the glass which is sometimes produced by the action of sulphuretted hydrogen, in spite of the protecting varnish, use is made of a glass slightly tinted rose or blue, or of a process (Lenoir process) whereby the film of silver is partly replaced by a layer of silver amalgam. The silvered glass is washed and sprinkled with a weak solution of double cyanide of mercury and potassium. The silver is partially dissolved in place of the mercury, which latter, becoming free, forms an amalgam with the silver which is white and adheres firmly to the glass. This reaction is activated by powdering with zinc dust.

Mirrors are also made with platinum (chloride of platinum) dissolved or suspended in lavender essence. The image is reflected directly by the platinum, without passing through glass. These mirrors are used for small objects in the ironmongery trade because of their coloured tint, for mir
use of small size and as electric lamp reflectors. Gilded mirrors are also made, known as Venetian or Nuremberg mirrors, etc.

Sources of Danger

Use of an amalgam in making mirrors exposes the workers to mercurial poisoning, either from direct contact or dust or inhalation of fumes. Old enquiries (Renk, 1889) are said to have shown that a workman in an eight-hour day inhaled 4.5 mg. of mercury in the form of fumes as well as dust, the mercury content of which over a period of eight hours per person might reach 2.5 mg. Intoxication is further favoured by particles of mercury adhering to the clothes, a danger to which not only the worker himself is exposed but also those persons in contact with him. The working clothes of a man using amalgam may contain more than 2.5 grm. of mercury and clothing which is smooth and close fixes the element more easily than others (Renk).

Risk exists during the handling of mercury (by carrying the troughs, during immersion, and recovery of the tin contained in the residue and heating the amalgam). Scrapping off the amalgam from old mirrors also exposes the workman to the risk of mercurial poisoning.

In the manufacture of mirrors by the use of silver nitrate and ammonia occupational risk is infinitely less than in the old method with mercury. Use of the cyanide solution to obtain a final coat of silver (Lenoir process) constitutes no risk if the workmen observe the elementary rules with care. On the other hand manipulation of the ammonical silver solutions may give rise to accidents. Thus an explosion occurred (in 1928) in a mirror factory where the silver solution was obtained by dissolving 40 grm. of silver nitrate in 100 grm. of water, adding 200 grm. of ammonia or a solution of 80 grm. of caustic potash in 200 grm. of water (solution 1). The reducing liquid (solution 2) took the form of an ordinary solution of sugar candy in dilute alcohol. Solutions 1 and 2 were cooled and filtered and then mixed and spread and diluted up to 10 litres. During work one summer a concentrated mixture had, accidentally been prepared beforehand, and on the introduction of caustic potash a precipitate was formed (fulminate of silver, silver amide, silver nitride) which had, dried, by evaporation. Organic dust coming into contact with this precipitate brought about an explosion, happily when no one was present (W. Meyer).

Silver nitrate causes pigmentation of the skin, nervous and digestive troubles, etc. Workpeople often use cyanide of sodium to remove the black pigmentation from the skin. In many American mirror factories, this preparation is placed at the disposal of the workers, who are unfortunately ignorant of the danger of the cyanides. The workman takes the product up in his fingers, rubs the discoloured areas on his skin and, if his hands are not then carefully washed with soap and hot water, a little of the cyanide remains on the skin or under the nails and so gets into the mouth (during eating or smoking, etc.). McMahon, of New York, in 1925, reported several severe cases of cyanide poisoning in mirror factories from this cause.

Statistics

In spite of the decreasing importance of the making of mirrors with a tin amalgam, it is interesting to cite by way of illustration some figures as to the ill effects the process had upon the workers. Between 1879 and 1883, 123 cases of mercurial poisoning in a working population of 170-180 were reported from Fürth (Bavaria). In 1885 out of an average number of 182 workpeople, mercurialism had caused 2,864 days of incapacity from work during the first five months and 1,210 days during the remaining seven months.

In general, the number of cases of mercurial poisoning increased in proportion to the number of years of employment. Thus, during the first and second years 21 per cent. of the workers fell ill, while from the second to the sixth year the percentage was sixty-one. After a certain length of time, however, the cases of poisoning appeared to diminish; they numbered 15 per cent. among workers with a duration of work varying between six and ten years and 3 per cent. among those employed for ten to seventeen years.

Cases were reported even within the first fifteen days of work, especially among women (80 per cent.), among whom there was a noticeable frequency of tuberculosis, miscarriages, combined with a high infantile mortality (65 per cent.). Finally, mercurial cachexia often appeared as early as the first year.

Hygiene

Adequate measures of hygiene have diminished the dangers notably. These have centred on re-arrangement of the workrooms and tables on which the process was carried on. Legislation requires at least 40 cubic metres of air per person, with locally applied exhaust ventilation for the removal of
the mercury vapour; duration of work limited to eight hours in the winter and six in the summer, and cessation of work whenever the temperature of the workroom exceeds 25° C.; medical examination every fortnight to detect the first symptoms of poisoning; installation of cloakrooms, washing accommodation and canteens; the wearing of overalls, etc.

In the various manipulations of mercury entailed, direct contact should be avoided as far as possible by using wads fixed to the end of rods such as were used already in the second half of the nineteenth century in the workrooms of St. Gobain, Cirey and Chauny. The mercury running off from the tables requires to be collected in closed receptacles, and the cleaning of all objects that have been in contact with the mercury (filtering cloth, purifying apparatus, etc.) should be effected by shaking them in an agitator in a closed machine.

In order to prevent risk of explosion in silvering, work should not be done with concentrated liquid nor with one that has been prepared some time beforehand. If the precipitate separates from the mixture, it should be redissolved by the addition of ammonia. The filters used with the silver solution should never be allowed to dry and all work should be done as far as possible in the absence of dust. In workrooms where varnish containing hydrocarbons is used, the floors should be impermeable and the ventilation adequate.

Openings on to a public road or neighbouring property should be kept closed. The varnish should never be applied in artificial light; it should be dried in a room separated from the silvering workrooms. If the varnish is made in the factory the work should be done in a special place constructed of non-inflammable materials. Materials necessary for the preparation of the varnishes should be kept in a special place to which access should only be allowed by daylight and where every possible precaution is taken against the risk of fire or explosion. The effluent from the factory should be neutralised before being allowed to pass into streams.

LEGISLATION

Women, children and young persons should be excluded from all processes in which dangerous materials are used (dangerous from mercurial poisoning, poisonous dusts, etc.). Compulsory notification of mercurial poisoning among glass polishers, and mirror-makers is enforced in the Netherlands. Compensation for mercurial poisoning is granted to workers in Italy, and in countries which have ratified the Geneva Convention (1925) and in those in which poisoning by mercury is scheduled under the Workmen’s Compensation Acts (see article *Mercury*).

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**Molybdenum**

French: Molybdène. — German: Molybdän. — Italian and Spanish: Molibdeno.

Molybdenum (symbol MO) is a rare element found in wulfenite (PbMoO₄) and molybdenite (MoS₂). After preliminary crushing, the ore is ground, passed through washers, grading machines, and subjected to the floating process. The scum, containing 15 per cent. of molybdenite, is taken up by washing and grading machines. The concentrates obtained at 40 per cent. are thickened in a filter and the humidity reduced by steam heating. The concentrates are often despatched in jute sacks lined on the inside with strong paper, or, where it is a case of foreign export, in barrels. A mine worked in Colorado is situated at a height of about 3,400 metres.

The rocks used as ore in general contain hardly over 0.7 per cent. of Mo sulphide. They have therefore to be enriched by mechanical means. The enriched ore used for the extraction of Mo contains 80-97 per cent. of sulphide.

The ore is transformed by roasting into oxide (MoO₃), which, heated in a current of hydrogen or in an electric furnace with carbon, gives metallic molybdenum. The latter is a grey powder, giving, at a very high temperature, a molten mass with a silver aspect.

Oxide of molybdenum is used in the manufacture of filaments for incandescent lamps. Winkler noted on the hands of workers handling these filaments, bluish stains, which he considered to be due to molybdenum dust which had penetrated into the skin and become oxidised.

After preparation of metallic-molybdenum in a sufficiently active form, it is submitted to the action of carbon monoxide at a minimum pressure of 150 atm. and at a temperature of about 200° C. At a pressure of 200 to 250 atm., there is gradually formed a very feebly quantity of carbonyl crystals, the chemical properties of which are similar to those of the other carbonyls. The oxidising agents attack it rapidly.
with the liberation of carbon monoxide (Mond). In 1924 Karantassis and Pradier made experimental studies in regard to the toxicity of molybdenum in the state of molybdate of ammonium. By way of the gastric system, the molybdate causes anorexia, colic, uncontrolled movement, trembling and dyspnoea. The molybdate injected is eliminated in the faecal matter and urine. The molybdenum is found in the lungs, the blood, the liver, the kidneys, the stomach, intestines and bones, etc.

The salts of molybdenum act as slow poisons and cause death, with symptoms of asphyxia. Their toxicity is not great, but they may produce chronic poisoning by accumulation. Molybdenum is less toxic than tungsten, which fact is in accordance with their respective atomicity. The toxicity of tungsten and of molybdenum is higher than that of chrome compounds. As far as concerns industrial practice, molybdenum has relatively slight toxic action, and authorities on the subject even consider it harmless (Loewy, Lehmann, Fischer). Its power of injuring the nervous system and the liver is not considerable except when in combination with carbonyl.

No legislative measures exist in regard to the handling or manufacture of molybdenum.

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Mother-of-Pearl

French: Nacre. — German: Perlmutter. — Italian and Spanish: Madreperla.

Mother-of-pearl or nacre is the name given to the inner part of the shells of the large marine bivalves — *Avicula (Meleagrina) margaritifera*, *A. macropetra* and *A. fucata* and others. They are chiefly found on the coasts of Ceylon, Manilla, Cuba, Panama, the Gulf of California, the South Sea Islands, and North-West Australia. They are obtained in the latter country by dredging rather than diving. The mother-of-pearl is more accurately the inner portion of the shell lining, formed of thin layers of superficial membrane and limestone secreted by the oyster and having a smooth iridescent surface. Gussenbauer investigated chemically and analytically the composition of the inner layer of the mussel shell and found it to consist chiefly of carbonate of lime and an organic substance known as "conchiolin".

The largest consumption of mother-of-pearl is in the button trade. It is used also for knife handles (fruit and dessert knives and forks), pocket knives, fans, lorgnettes, opera glasses, ornamental inlay and fancy goods in general.

The shells are first cut by means of a circular saw, usually in a damp state. The shells are thereafter plunged into hot hydrochloric acid and pumice stone is subsequently applied.

The next stage of the work differs according to the product. For opera glasses the shell is next ground with sand on a wet grindstone; thin plates of the material are then glued together and again ground on a corundum grindstone. All these operations are performed in a wet state and only polishing is done dry with emery paper on a cloth buffer. The head for the glasses is worked on a lathe and at this operation much dust is evolved.

For flat buttons mother-of-pearl is cut into rounds, then worked successively on a turning lathe and a boring machine. The buttons then pass to an earthenware drum containing water and are subsequently placed in pots containing peroxide of hydrogen and these pots are allowed to stand in water which is heated. The buttons are finally polished with sawdust and stearine.

The chief source of risk is constituted by the extremely fine dust liberated during all processes, whether wet or dry (Birge and Havens).

Pathology

As early as 1869 Englisch described an affection characterised by osteitis (found amongst young workers) which was later designated "Conchiolin osteomyelitis" or "Mother-of-pearl workers' osteomyelitis". Hirt (1875) regarded the trade as a highly dangerous one. Another authority states however that workers handling real mother-of-pearl are but little affected. Conditions were subsequently studied by Gussenbauer (1875), Weiss (1885), Fischer (1888) and others.

The etiology is still somewhat obscure, though the symptoms are commonly attributed to the constituents of the dust, which is believed by Gussenbauer to set up embolic processes in the bone. Gussenbauer speaks of this peculiar affection of the bones as due to "conchiolin", an organic substance present in the shells, or more exactly to the absorption of carbonate of lime from the shell particles inhaled. Levy blames the sludge from the grinding operations and its contents, viz. organic matter clinging to the outer surface of the shell. Poicaré remarks on the advisability, in seeking the cause of considering the influence of organic particles in a state of decay and also the composition of the mineral content, while Levy suggests that the disease may be due to pyogenic organisms.
contained in the water of the grinding trough. A number of cases of mother-of-pearl workers’ osteomyelitis described chiefly by French and German authors amounted to 32 in 1907: Englisch 6, Gussenbauer 6, Weiss 11, Fischer, 2, Levy 5, Tridon and Broca 1, and Teleky 1 (a single case amongst 150 mother-of-pearl workers examined in Vienna). Single cases have also been recorded from time to time in the annual reports of hospitals in Vienna, but such cases are now much rarer. The above-mentioned cases, with the exception of those cited by Levy, affected workers between fifteen and twenty years of age. In an enquiry conducted in Bavaria in 1909 Koelsch did not meet with a single case. Birge and Havens (1930) refer to the disease, but make no comment in regard thereto. Oliver found no confirmation of the existence of such a disease when examining the mother-of-pearl workers in the shops of Sheffield where grinding was done wet. Gerbium in 1927 carried out an investigation in a factory for the manufacture of mother-of-pearl goods without finding any case of osteitis. Also he was able to ascertain that no doctor in the district, in which the factory had existed for nearly a century, had met with any case of osteitis. In 1928 Bernstein reported a case of periostitis and infectious disease of the lower jaw and a case of inflammation of the metatarsus affecting a worker aged eighteen whose father, likewise a mother-of-pearl worker, had suffered from the same trouble in his youth.

According to Weiss, who had examined twelve workers suffering from the disease, osteomyelitis commences with violent rheumatic-like pains involving thickening of the bones after one or several weeks, accompanied by fever. The long bones are chiefly attacked, but bone plates may also be involved. The swelling usually commences at the end of the diaphysis and spreads towards the centre of the bone. Towards the epiphysis it ceases suddenly. The nearest joint is therefore only indirectly involved or not at all. The clinical picture is that of a subacute osteomyelitis accompanied by osteitis and periostitis of the ends of the diaphysis. The soft tissue covering of these is mostly unchanged or only slightly swollen. The scapula is often affected at the lower corner, and the ulna and radius mostly at the upper end. It is curious to note that the lesion never affects the first metacarpal and metatarsal bones while it commonly attacks the others.

Cases have also been reported in which the affection was localised in the jaw bones and bones of the lower limbs. The symptoms would appear to indicate the second stage of ossification, namely fusion of the diaphysis starting preferably at the point where ossification proceeds most rapidly. This is also borne out by the fact that the victims of the disease are in most instances very young. However in five cases described by Levy four were over twenty-five years of age and the oldest was thirty-one. After swelling and pain have lasted some time (several weeks) they gradually die down and disappear entirely, though in certain exceptional cases a permanent thickening of the bone remains. Opinion as regards development of necrosis of the bone appears to be doubtful.

Differential diagnosis is facilitated by the characteristic seat of the affection taken in conjunction with the patient’s occupation. Mother-of-pearl workers are also very much exposed to the risk of chronic diseases of the respiratory system — cold, catarrh, bronchitis, and especially to pulmonary tuberculosis.

Genkin reported in 1931 two cases of asthma affecting two workers which he had an opportunity of noting in Moscow, of whom one was a turner and the other engaged on sawing mother-of-pearl. Attacks characterised by fits of coughing, and air hunger obliged the victims to leave their work. But these symptoms disappeared on cessation of work only to resume as soon as the workers again became exposed to mother-of-pearl dust. From the pathogenic point of view, Genkin attributed great importance to the constitution of the workers in question, both of whom might be described as the neuropathic subjects of a vagotonic type.

As is revealed by enquiries effected by Teleky, Bann and Götzl (1907), Koelsch (1909), etc., the individuals in question were mostly weak, undernourished, pale and unfit for military service on account of their general health. The reason for the very high incidence of pulmonary tuberculosis amongst such workers may be sought in the working conditions (low wages, small badly ventilated workrooms without adequate dust exhaust systems), by defective posture causing frequent curvature (kyphosis) — this through standing on one foot and working the latex with the other — flat foot and varicos veins, etc. Of 390 deaths reported between 1895 and 1905 amongst button makers (mother-of-pearl workers were not given separately) who
were members of the Vienna Sickness Fund, 272 (69.7 per cent.) were due to tuberculosis, and amongst 150 mother-of-pearl workers examined in 1907, 93 only had healthy lungs (Teleky). Out of 127 cases studied by an insurance company, 48, or 37.8 per cent., died of pulmonary tuberculosis and 14, or 11 per cent., of other affections of the respiratory passages (Birge and Havens). Of the 20 mother-of-pearl workers examined by Koelsch, 8 showed infiltration of the apices of the lungs.

Out of 127 cases studied by an insurance company, 48, or 37.8 per cent., died of pulmonary tuberculosis and 14, or 11 per cent., of other affections (Birge and Havens). The incidence of tuberculosis among mother-of-pearl button makers in Iowa reached 2.6 per cent. in 1920, whilst for the general population it was only 1.2 per cent., and amongst those workers not manipulating mother-of-pearl, 1.02 per cent., 22 out of 33 workers engaged on cutting buttons, who were examined by Birge and Havens, showed symptoms of tuberculosis. The 22 cases in question comprised workers who had followed the occupation for at least five years. On the other hand, the percentage of 2.6 above referred to comprised workers in the button industry who had been engaged on the work for less than a year — too short a period to permit of the effects of the dust being felt. It must be added, however, that in large factories health conditions are very much superior to those met with in small workshops.

Mother-of-pearl workers are besides exposed to rheumatism, indigestion and ocular fatigue (Birge and Havens), to conjunctivitis as well as infections of the buccal cavity often developing suppuration. Koelsch has noted frequent inflammation of the throat, as well as callosities, rhagades and ulceration on the hands. The latter are said to be due to the caustic action of the lime (Jolly). Barres and Courtois-Suffit-record the appearance of a redness and swelling with vesication round the nails, said to be due to the dust produced in course of "pressing" the buttons (Herschheimer). Neisser records severe epistaxis, pricking of the eyes, inflammation, bronchial and even gastric irritation caused by the dust of shells from certain molluscs of a special kind (burghaus, burgadines), in a pearl factory in France.

**Hygiene**

Dust should be reduced to a minimum in all operations and especially during work in a dry state (cutting and polishing). All efforts should be made to avoid splashing since drops projected, during work in a wet state, carry with them fine particles which are later disseminated as dust after desiccation. All grinding mills and apparatus likely to produce dust should be placed under hoods provided with effective dust exhaust ducts.

In wet grinding the method by which the lower part of the blade is dipped in water is preferable to mere damping of the shell, for dust still escapes with this latter method and some authors hold that this dust would be more harmful even than dry dust. One method followed is to let water drop continuously on the revolving piece, but the dust removed thus is but slight in comparison to the total amount produced, and thorough damping of the material is to be preferred. A method proposed by best only damping of the surface. Levy insists on the importance of removing the grinding sludge and proposes with this intent improved construction of the casing of the grindstone.

There is urgent need for improvement of general conditions in the workshops and of better industrial organisation (reduction of the working hours especially for women and young persons, prohibition of domestic work or work in small workshops under unhealthy conditions). As far as possible manual work should be replaced by mechanical methods.

**Legislation**

In France young persons under eighteen are excluded from dry processes in the mother-of-pearl industry where dust is freely liberated in the work-room; in Spain young persons under sixteen and women under twenty-one are excluded from dry processes in the industry (cleaning and polishing). Osteitis is compensated in countries which provide compensation for occupational diseases of the bones.

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Mouth and Teeth (Occupational Affections)

Occupational affections of the mouth and teeth and their adjoining parts form an interesting chapter in industrial pathology which affords scope for study, from the aetiological point of view, under two separate headings: one dealing with the bony parts—the teeth and jaws—and the other dealing with the soft parts of the mouth and its immediate neighbourhood.

**OCCUPATIONAL LESIONS OF THE BONY PARTS**

**Teeth**

Occupational lesions of teeth can be caused by mechanical means, acute or chronic, by certain kinds of dust, and by various poisonous substances. On the other hand, dental caries and occupations are closely connected. Finally, lesions of the teeth, particularly of the alveoli following injury, must not be forgotten. All these causes provoke lesions or deformities, colorations or affections of the dental substance, with looseness and falling out of the teeth.

**Wounds** (injuries) of the teeth may affect either the tooth alone or its connection with the dental alveolus, or the alveolar processes, or the bone of the jaw. The action varies according to the nature and intensity of the acting force, its direction and point of application. The front teeth are naturally more exposed to these accidents, all the more so as they are relatively not so well fixed to the jaw. (See article "Diamond Cutters"; under Splitting.)

**Fractures of teeth** may be of different degrees, from simple cracks or fissures to more or less extensive detachment of parts, causing pain and troubles of mastication and speech. If the pulp cavity is not opened, the dental pains rapidly disappear; if it is opened it may cause intense pain with inflammation, and quite a train of complications. The broken edge of the teeth may injure the lips or the tongue. A cure may be effected when the pulp is not exposed and is not infected, which is rare and usually only met with in young subjects. Treatment lies in the hands of the dentist.

Under the term **displacement** is included the loosening of a tooth in its socket, or its detachment or, more rarely its impaction into the jaw, which may be accompanied by a simultaneous fracture of the tooth. In these various cases pains more or less violent arise in the soft parts and the dental pulp. Infection can sometimes cause grave complications. Correct treatment lies in fixation of the tooth.

**Violent traumatism** can cause lesions of the jaw and the soft parts of the mouth: fractures and displacements of the upper and lower jaws with their ordinary sequelae, such as traumatic limitation of movement and secondary ankylosis.

Of other mechanical lesions, one which affects especially the incisors following on wear and tear or a local strain is characteristic of certain industries, constituting occupational **stigmata**. These deformities, due to wearing down of the incisors, have been noticed for a long time, for example, among soldiers who were accustomed to bite off the end of cartridges with their teeth; among the inhabitants of Arctic regions who complain that their teeth suffer from being obliged to soften by mastication leather used for sewing; among players on wind musical instruments and especially among cavalry trumpeters, who hold the trumpet against their teeth; among shoemakers and upholsterers who have a habit of putting nails in their mouth and pushing them out one by one between their teeth, which become worn down in the shape of a half moon or a groove; among designers and teachers, who have a habit of holding pencils between their teeth; among persons who have the habit of cutting with their teeth the material with which they work, for instance, dressmakers who bite through threads, cigar makers who bite the end of cigars, and brush makers who bite the bristles.

Among these trade deformities should also be mentioned those of glass blowers which are quite characteristic (see article "Glass"). Among smokers, who have the habit of constantly holding the pipe between the teeth, a "pipe hole" is situated sometimes on one side of the mouth, sometimes on both sides, and most often between the incisors and canines.

**Causes of Injury**

**Teeth.**—Among the dusts which originate numerous lesions of the teeth, metallic dusts must be mentioned; they cause deposits in the middle of the teeth and a brownish red coloration.
among iron-workers and a greenish grey and dark green among copper and brass workers. In the latter case gingivitis has been noticed as well. Work on mercury and its compounds, such as the sublimate, fulminate and nitrate, causes a special coloration of the teeth (see article "Mercury ").

Different colouring materials used in powder may similarly colour the teeth.

For a long time the injurious action of the dust of flour and sugar upon the teeth in certain industries has been recognised: e.g. millers, bakers, confectioners, makers of gingerbread, pastrycooks, and workers in sugar refineries and chocolate factories become affected with dental caries (see articles "Bakery Trade" and "Sugar Refining ").

The treatment of the caries does not present anything special, but prophylaxis should be established from the time of choosing the trade, and while carrying it on, by examination and appropriate dental care.

Premature falling out of the teeth among salt-workers (Franz) is disputed by Mayerhofer, who does not recognise dental caries as a disease specific to the industry. According to the investigations of this author, those employed in the salt industry who do not come in direct contact with this substance show the same percentage of dental caries.

Pathological changes in the teeth can similarly be found among workers who come into daily contact with acids, whether such mineral acids as hydrochloric, sulphuric or nitric acids, or such organic acids as acetic and citric acids. But a number of workers show the same lesions as workers in contact with acids, viz. those dealing with soda, nitration, cellulose, explosives, accumulators, engravers, metal workers, and others.

Voigt found the same characteristic lesions in 40 workers in an acid factory that Adloff did among 21.5 per cent. of 125 workers whom he examined. In German acid works, Koelsch (1923) found lesions due to acids as follows:

<table>
<thead>
<tr>
<th>Acid</th>
<th>No. of workers</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphuric</td>
<td>124</td>
<td>26</td>
</tr>
<tr>
<td>Hydrochloric</td>
<td>32</td>
<td>84, 30</td>
</tr>
<tr>
<td>Nitric</td>
<td>30</td>
<td>93, 32</td>
</tr>
</tbody>
</table>

That is, a total of 138 workers affected out of 397 employed in acid work or 34.7 per cent.

We are concerned here essentially with a molecular necrosis, a destruction of the organic substance and then of the mineral substance of the teeth, necrosis the beginning of which depends on personal predisposition, the nature of the work, and the measures taken for the protection of employees. The destruction of a tooth is complete in two or three years. The troubles may begin as quickly as a few weeks from the commencement of work; they are due to the action of acid vapours which with respired air pass over the most exposed teeth and condense in the mouth. The saliva made acid by these vapours decalciﬁes the dental substance, so that it is no longer able to resist mechanical action or the micro-organisms of putrefaction. The first sign consists in a blunting of the teeth, which lose their brilliancy and in time get rough, marbling with brown patches; they become sensitive to touch and to changes of temperature and to acids. The teeth become tender and brittle diminishing in length until they completely disappear. The incisors are cut with a bevelled edge at the expense of the thickness of their substance; the polished surfaces of the upper teeth form with those of the lower teeth an open angle in front, or rub directly ﬁat the one upon the other, which interferes with mastication. These troubles disappear fairly rapidly. The troubles indicated have nothing to do with ordinary dental caries, for they never result in the formation of cavities and loss of teeth.

Prophylaxis consists in washing the mouth with alkali solutions, such as 1 per cent. of borax and 3 to 5 per cent. of soda; in periodical examinations of workmen made by a doctor or dentist; and in the application of technical measures adequate for preventing the diffusion of acid vapours wherever they can be adopted. Materials used in respirators should be moistened by an alkali. Workers should be forbidden to adopt the bad habit of placing a wad of cotton wool or a piece of rag between the teeth with the object of protecting the respiratory passages. These articles as a matter of fact become impregnated with acid vapours and act in the contrary way.

A particular form of dental caries has been observed by Lazarus among makers of indiarubber dentures, which the author attributes to the rubber, whilst Breve attributes it to the subside of carbon, and other writers to cinnabar. It results in the roots getting into a state of suppuration: pressure causes a clear, yellow, foetid discharge to ooze from the dental alveoli. Signs of early necrosis of the
bone are noticed with swelling of the lymphatic glands of the region. Pre-existing dental caries favours the establishment of these lesions.

Numerous dental lesions accompany the production of many forms of industrial poisonings, as by lead, manganese and mercury (see those articles). In lead poisoning the teeth rarely show any typical lesions. The colour and greyish-brown deposits which are generally seen are not specific to lead poisoning. Lead dust, just like any other foreign material, may be deposited on the gums, more particularly at the level of the neck of the tooth. Hintze found among the workmen of an accumulator factory a deposit of from 0.35 to 0.48 per cent. of lead. Never-theless, as in all the other organs of the body, deposits of lead may occur in the teeth at the level of the dental stoma. (Carbon dust of an electric arc.) Hintze found 0.038 per cent. metallic lead in the crown and 0.033 per cent. in the roots.

Trophic troubles, which accompany carbon monoxide poisoning, similarly cause falling of teeth which appear unaffected, but may fall after a more or less long period after the poisoning. Those affected complain of slight rheumatic pains or of swellings of the corresponding parts of the gums and of the cheeks. The cure of the alveolar lesions which follow is long, sometimes accompanied by deep suppuration. Nothing unusual is seen on the roots of the teeth either before or after they fall out. Sometimes the teeth, which already rock in their sockets, can be made firm again when the general effect of the poisoning rapidly recedes. Falling out of the teeth also occurs following trophic troubles due to a lesion of the trigeminal nerve caused by the action of vapours of trichlor-ethylene.

Jaws.—Among the occupational diseases of the jaws, phosphorus necrosis occupies the first place (see articles "Matches" and "Phosphorus").

A similar lesion has been recently (1925, United States) reported among some workers in watch factories which is ascribed to the action of mesothorium (see that article).

Yet another lesion of the jaws has been noticed among the turners of mother-of-pearl, more particularly among the young workers at the commencement of puberty. In fact, in addition to progressive subacute osteomyelitis occurring as a sequela of the action of the fine dust of mother-of-pearl, which especially affects the long bones, lesions of the jaws (and more especially of the lower jaw) are reported. Accompanied by accentuated pains, even when the teeth are intact, a painful thickening of bony consistence spreads in fusiform shape along the lower jaw. Generally a concomitant ankylosis of the jaw is observed. Suppuration or bony necrosis is rare. For the most part the manifestations recede without any permanent injury; in other cases there remains a swelling of bony consistence indistinctly defined or a general thickening. There is a tendency to recurrence when the occupation is resumed.

The essential cause of this affection is not well understood; the osteomyelitis which is situated at the end of the diaphysis and of the epiphysis is attributed generally to troubles of ossification caused by the absorption of the fine pearl dust which reaches the bony tissues by absorption.

Diagnosis is easy and depends on knowledge of the trade and age of the worker, the seat of the lesion at the extremity of the lower jaw with a fusiform swelling in the middle, and freedom of the joint. Treatment is on the usual lines: local application of cold and ointments of mercury or iodine, with iodide of calcium internally.

The connection between dental caries and occupations is repeatedly emphasised in literature. But the different statistics published have not completely cleared up the situation. Up to the present there has been less dental caries in the rural than in town populations, but according to recent studies it seems that dental caries extends also to the country, due to the consumption of bread of beet flour, replacing black bread, and of sweetmeats to changes in food, and to alcoholism.

An investigation by Lührse on dental caries in the various trades shows that this disease occurs with the following frequency: agriculturists, 18.1 per cent. of teeth; clerks and employees, 21.8 per cent. of teeth; bakers and pastry cooks, 27.6 per cent.; tailors, 18.4 per cent.; café waiters and cooks, 19 per cent. A statistical table drawn up by Rose dealing with 353,377 teeth, possessed by 11,874 persons, shows that 26.4 per cent. of teeth were diseased and only 5.9 per cent. were free from caries. As regards the trades of the persons examined, the agriculturists showed 21.4 per cent. of diseased teeth and 9.5 per cent. without caries; masons, 25.9 per cent. of diseased teeth and 8.1 per cent. without caries; millers, 26.5 per cent.
of diseased and 4.2 per cent. without caries; waiters and cooks, 30.4 per cent. diseased and 4.2 per cent. without caries; clerks, 32.3 per cent. diseased and 2.4 per cent. without caries; bakers; 39.6 per cent. diseased and 2.1 per cent. without caries; pastry-cooks, 51.3 per cent. diseased and not a single tooth free of caries.

It can be said that generally the tendency to caries depends on the constitution of each individual, but particularly on the standard of cleanliness and care of the teeth. It follows that trade groups generally made up of healthy persons show very little dental caries especially when there is complete understanding as to the correct care to give to the mouth. The high percentage of dental caries in the “alcohol group” of trades, including waiters and barmen, reported by various writers, is explained by diminished constitutional resistance following the abuse of alcohol, which, according to Bunge, explains also the marked tendency to caries among the children of drinkers.

**Diseases of the Buccal Cavity and Adjoining Parts**

Like the teeth, the soft part of the mouth and the adjoining regions can be damaged by various trade conditions, such as injuries, temperature, dust, poisons, or infections.

**Injuries.** — Among the injuries should be noted the different haemorrhagic wounds which result from external blows, most usually accompanied by lesions of the teeth or the jaws. Generally they are accompanied by inflammation of the buccal mucous membrane and tongue, of varying intensity with redness, swelling, exaggerated salivation, and epithelial desquamation.

Among the chronic injuries must be classed inflammatory thickening of the lips of musicians who play wind instruments from pressure of the mouthpiece, or among glassblowers from pressure of the blowpipe. Sores and cracks on the lips, ulcerations of the tongue and buccal mucous membrane are found, for example, among upholsterers, shoemakers and glassblowers, and these, although slight, can form the portal of entry for infections of every kind.

**Fatigue, exertion.** — Glassblowers and musicians who play wind instruments frequently show a relaxation of the musculature of the cheek, so that it swells into a semi-sphere. Local irritation constantly repeated, due to this stretching of the cheek walls, causes thickening of the epithelium of the mucous membrane, of which the most superficial cellular layers become macerated in the saliva (the quantity of which is often increased) and then detached. The thickened and rough mucous membrane appears grey and whitish on the surface with patches of different sizes sprinkled over it. Subjective troubles are very slight or altogether lacking.

**Differential diagnosis,** guided by a knowledge of the occupation, must be made between syphilitic plaques, which are never isolated upon the mucous membrane of the cheek, but are found much more often upon the tongue or gums, are temporary, and ulcerate rapidly, and buccal leukoplakia, which is found most often on the tongue and the labial commissures, while with glassblowers these parts are not affected.

Exaggerated expiratory pressure sometimes causes among glassblowers a characteristic condition: pneumatocele of the parotid, due to the penetration into Sténon’s duct and from there into the parotid of air which the mouth has compressed before forcing it into the pipe (see article “Glass”).

The pneumatocele may occur during a violent effort while speaking or during mastication; further, debris of food can pass along the enlarged Sténon’s duct and cause a parotitis. According to Scheler, 6 to 10 per cent. of glass workers have this condition. Koelsch has seen it in a number of cases. Diagnosis does not present any difficulty. Treatment consists in the application of compressed ball-shaped pads made of feathers on the region of the maxillary articulation to prevent the accumulation of air. This treatment as a matter of fact is not very satisfactory. Serious cases are quite unable to continue blowing and a change of occupation is required. Abolition of this industrial disease depends on the introduction of a blowpipe worked by compressed air.

**Occupational neuroses,** following on excessive use of the motor or sensory apparatus, may occur in the region of the mouth, favoured by a general neuropathic condition. A neurosis of the mouth and the musculature of the tongue may be cited, for example, among such musicians as flautists and clarionette players—a neurosis which takes the form of painful muscular contractions as soon as they try to put the mouth in the position required for playing.
In this pathological group may be placed disturbances of the nerves of taste, due to overlong practice, among tasters of wine, spirits, spices and tobacco, disturbances which manifest themselves either by paresthesia, by metallic or bitter taste, or by anaesthesia (loss of power to taste). Complete or sufficiently long cessation of work is essential to treatment.

High and too low temperatures. — The action of abnormally high temperatures to which foundrymen, engine-drivers and stokers are exposed, causes, by direct thermic irritation of the trigeminal nerve, or by vaso-motor disturbances, neuralgias accompanied generally by a typical erythema of the skin and especially of the side of the face most exposed to the heat.

Localised burns of the mouth and the adjoining parts are met with occasionally among glassblowers; lesions of the buccal cavity, due to the action of steam or hot gas, are met with also among engine-drivers and stokers of steam engines. But these lesions are not generally associated with any serious injury, or only with hyperaemia or the formation of phlyctenules; at any rate they are not in any way specific.

Local action from cold also causes neuralgia on account of vaso-motor troubles, and rheumatic affections of the articulations of the jaws which are accompanied by pain, swelling and interference with movement, e.g. rheumatic limitation of the movement of the jaw. Necrosis of the articular cartilages, ankylosis or displacement of the articulation may occur as sequelae of chronic arthritis. Prophylaxis consists in the use of screens against heat, and of localised protection against intense cold.

Dust. — Manifestations of more or less acute irritation are found on the mucous membrane of the upper respiratory passages, the mouth and pharynx, according to the nature of the contamination due to dust.

Excoriation and deglutition favour rapid elimination of dust from the mouth. Stomatitis is rare; nevertheless dust of mother-of-pearl may cause inflammation with a cushion-shaped swelling of the front part of the gums.

Chronic catarrhs of the naso-pharynx are more common, often associated with polypi, swelling of the follicles, and catarrh of the Eustachian tube. Dust which is deposited in the nose often collects together into hard masses or rhinoliths.

Another sequel of dusty work among pigments, aniline colours, coal or metals, consists in discoloration of the teeth, lips, gums and buccal mucous membrane. Work on iron gives a reddish brown discoloration to the gums; silver a greyish colour, copper and bronze a reddish or brownish black, or greenish blue. These colorations of the gum are accompanied with irritation of the mucous membrane (gingivitis) or coloured incrustations in the layers of the tooth. A hundred and fifty iron-workers presented brown stains on the teeth, especially on the edge of the lower teeth. Nickel workers show, according to Miller, a coloured incrustation on the teeth due to a metallic deposit. Lewin did not find coloration among copper workers, but on the contrary he observed a red inflammation with non-painful swelling of the border of the gums. Dust's of zinc and cadmium leave sometimes blackish deposits and cause catarrhal stomatitis which, however, according to Koelsch is very rare. Seifert has sometimes found among smelters of zinc a dark line (see article "Zinc"). These different colorations of the teeth of metal workers have often been confused with the lead line, which is however too characteristic for a medical man to mistake. It must not however be forgotten that all metals contain lead as an impurity.

Koelsch has seen a very heavy line among brass-workers due to the dust containing 10 per cent. of lead.

Prophylaxis requires the employment of measures of protection appropriate to each kind of dust, with care of the mouth especially after work.

Poisons. — Certain industrial poisons act upon the mucous membrane of the mouth and pharynx either directly as a result of absorption in the form of dust, gas, or liquid, or indirectly during elimination by the saliva, or mucous glands, of poison absorbed into the system, which thus comes in contact with the mucous membrane of the buccal cavity, causing stomatitis of excretion. These two actions may occur simultaneously.

Irritant lesions occur in acute as well as in chronic poisoning, lesions aggravated to the highest degree by the presence of carious teeth or roots, or any other cause of irritation.

Prophylaxis can, speaking generally, be efficiently secured by the use of adequate respirators, the filters of which contain appropriate chemical substances, or by catching the harmful gases or dust at their point of origin, which enables the most serious troubles to be avoided. Other prophylactic measures must not be neglected, such
as instruction, cleanliness, and choice of workmen.

**Lesions in the Course of Poisonings**

1. The halogens (chlorine, bromine, iodine, and fluorine), especially if they are concentrated or if they act continuously over a long period, may cause symptoms of irritation of the mucous membrane of the nose, the mouth and pharynx, and of the gums, with salivation and a tendency to ulceration, giving rise to catarrhal and ulcerative stomatitis. Vapours of bromine and iodine cause besides a yellowish-brown discoloration of the gums.

2. The same lesions, i.e. catarrhal stomatitis with a tendency in serious cases to ulceration, are caused by sulphur anhydride, sulphuretted hydrogen, hydrocyanic acid, hydrogen telluride, and ammonia. Such cause, in very feeble concentration, violent irritation of the mucous membranes, a sensation of burning, constriction of the throat, and the formation of ulcers and later of scars. Treatment consists in the use of astringent washes, and touching or cauterising ulcers by ordinary means. Prophylaxis consists in washing out the mouth, in ordinary measures of protection against injurious gases, and finally in mechanical removal of the gas.

3. Aids, when strongly concentrated, occasionally cause cauterising of the face, the lips and the mouth, with the formation of ulcers and later of sores. Characteristic white sloughs are caused by hydrochloric acid; others reddish brown or black by sulphuric acid, and others yellow by nitric or chromic acids. Hydrochloric acid requires special mention for with average strengths it causes in certain cases, for example in the preparation of cleansing solution for soldering and in zinc plating, by the action of its fumes, serious irritation of the mouth and pharynx, while lesions of the trachea as far as the bifurcation have been occasionally observed, which lead to necrosis with the complete shedding of the mucous membrane and oedema of the glottis. The part played by a certain local predisposition is important.

4. Lesions of the mouth accompany phosphorus necrosis (see article "Phosphorus") and also acute or chronic poisoning by arsenic, antimony and bismuth (see those articles).

5. Alkalis and compounds of alkaline metals, more particularly soda and potash lyes, quicklime, chlorides of lime, calcium cyanamide, baryta, etc., rarely cause lesions of the buccal cavity. But small lesions in the form of ulcerations are frequently found around the corners of the mouth and the nostrils. Serious lesions from irritation of the buccal cavity, with formation of sloughs of a dirty greyish white colour, and deep ulcers only result from accidents and bad management.

6. More or less serious gingivitis with small ulcerations is met with among workers in chloride of lime. The dust of soda, lime and cement have a strongly irritating action on the nasal mucous membrane, an action which is characterised by catarrhal inflammation, polypoid excrescences, ulceration at the orifice of the nostrils, and, on the nasal septum, by perforation of cartilaginous septum.

Koelsch found among 600 cement-workers 26.6 per cent. of cases of hypertrophy and of polypi of the nasal mucous membrane, 2 per cent. of ulceration, 1.7 per cent. perforation of the septum of the nose.

7. Manipulation of alkaline chromates frequently causes irritation of the buccal cavity, and often small ulcers which have little tendency to heal, and generally are of a yellow colour (ulcerative stomatitis); they are situated generally upon the tonsils, the arch of the palate or the soft palate, and may even penetrate to the bone. Frequently small ulcers on the skin are found around the orifice of the nose and of the mouth, most often on the cartilaginous septum of the nose, sometimes even with perforation. In making a diagnosis the great resemblance of these lesions to syphilitic lesions of the palate must not be forgotten.

8. Various metals, such as iron, nickel, copper, and silver, cause incrustations upon the gums and are deposited there in the form of dust (see above). It is necessary to differentiate between these deposits and coloration of the gums, especially at their border, consequent on reabsorption of metal in the course of general poisoning.

In argyrism, or chronic poisoning by silver, greyish coloration of the mucous membrane of the mouth, borders of the gums, and parts of the cheeks touching the teeth is found (see article "Silver"). Chronic lead poisoning is accompanied by characteristic symptoms, such, for example as: a particular foetid smell of the breath, due probably to excretion of lead by the saliva and to lack of cleanliness of the mouth; stomatitis often accompanied by dental caries which Koelsch considers in certain cases at least to be a gingivitis or stomatitis originating from lead; the lead line; swelling of the salivary glands; and troubles of taste and smell (see article "Lead Poisoning").

Chronic poisoning by mercury also causes from the beginning lesions of acute stomatitis, purulent gingivitis, or inflammation of the pharynx aggravated by personal susceptibility and especially by the particular state of the buccal mucous membrane (see article "Mercury"). It is interesting to note that compounds of mercury do not cause typical lesions of the buccal cavity, and are not generally associated with stomatitis and hyper-salivation.

The dust of sublimate and fulminate of mercury, aided by the action of sweat, causes local irritations and ulcerations around the opening of the mouth and the
nostrils. This dust in powder or in concentrated solution may cause ulcers of a bluish grey colour.

Industrial poisoning by copper and its salts is rare; Koelsch has never found it. Nevertheless a case of excessively painful angina from the dust of verdigris and another case of chronic inflammation of the salivary glands from copper have been reported (Chauffard).

**Chloride of zinc** causes ulceration with white sloughs which are dry and tenacious upon the skin or rather upon the mucous membrane of the mouth. Convalescence is accompanied by lesions which are generally nutritional: skin eruptions of various kinds, swelling of the mucous membrane of the mouth and palate, fungoid gingivitis, pseudo-diphtheritic inflammation of the mucous membrane of the pharynx, and ulcerative tonsillitis.

(9) In acute poisoning by **carbon monoxide** among other general signs may be seen rose red spots on the face and mucous membranes. Convalescence is accompanied by lesions which are generally nutritional: skin eruptions of various kinds, swelling of the mucous membrane of the mouth and palate, fungoid gingivitis, pseudo-diphtheritic inflammation of the mucous membrane of the pharynx, and ulcerative tonsillitis.

(10) Among the **hydrocarbons** of chlorine which cause lesions of the mouth and the adjoining parts, the following should be kept in mind: tetrachloromethane (hydrogen tetrachloride) which decomposes with heat, for example, when used as a fire extinguisher, and sets free chlorine which, mixing with the moisture of the air, forms hydrochloric acid. The wrong use of extinguishers, as, for example, when they are placed in the direction of the wind, can cause irritation of the mucous membranes.

Ethylene, which causes irritation of the mucous membranes of the mouth and pharynx, especially when it contains certain impurities such as wood spirit, is one of the substances which cause lesions of the mouth and the pharynx.

(11) **Alcohol**, especially denatured alcohol, sometimes causes irritation of the conjunctiva of the mucous membrane of the mouth and pharynx with salivation, nausea, vomiting, and cough, which depend on the product of denaturing, such as wood spirit, oil of wood spirit, or pyridine. High temperatures favour evaporation and consequently increase the lesions.

(12) **Compounds of cyanogen cause**, among other conditions, congestion of the head, congestive hyperaemia of the mucous membrane of the mouth and pharynx, tickling and dryness, a sensation of constriction of the throat and oppression of the chest. This hyperaemia is noticed almost specifically when cyanamide and alcohol are simultaneously absorbed.

(13) **Tar and its derivatives**... Workers who are in contact with tar, pitch, phenol, etc., show generally a yellowish, or blackish-brown coloration of the skin of the face and uncovered parts, and very characteristic symptoms of cutaneous irritation: acne, ulceration, swellings, etc. The direct action of the sun exerts a photodynamic action and causes in addition among workers in pitch an acute erythema with swelling and itching, especially of the face. Among those suffering from chronic poisoning by benzene (see that article) haemorrhages from the gums are frequent at the time of teeth extraction.

**Mono and dinitrobenzene** cause a bad taste and a burning of the mouth and pharynx, tiny spots on the tongue, dryness and a sensation of thirst, as well as a greenish-blue coloration of the mucous membrane; the gums may show a bluish-black line (see articles relating to these substances). The nitro-compounds also cause an analogous clinical picture, although of less intensity.

Trinitrotoluene which often contains as an impurity tetrinitromethane causes, in addition to violent irritation of the respiratory passages (pulmonary oedema), salivation and tickling of the pharynx.

Similar effects are found with the aromatic amido-derivatives: aniline, toluidine, xylidine, tetraniromethane.

**Carbolic acid** causes a violent irritation of the mucous membranes with the formation of white slough.

Other aromatic compounds have an especially irritating action on the mucous membrane. Trinitrophenol, for example, causes in the vicinity of the mouth a bitter taste, a catarrhal stomatitis, a yellow coloration of the teeth, a greenish-yellow coloration, as well as irritation of the skin, the conjunctiva, and nose. The same symptom group may be seen with certain aniline colours. Trinitroanisol causes strong irritation with ulceration, inflammation of the mouth and pharynx.

(14) **Vegetable poisons** can similarly exert their properties during their manufacture; thus pilocarpine and eserine cause an excitation of the flow of saliva, atropine and morphine cause ulceration of the mouth; while euphorbia, veratrine and pulsatilla give rise to inflammation of the buccal mucous membrane. The ethereal oils contained in hops may cause eczema of the lips, stomatitis, inflammation of the pharynx and sometimes of the nose and conjunctiva. Inhalation of oil of turpentine, especially when it is used as an impurity oil of pine, extracted by dry distillation of pine roots, causes irritation of the mucous membranes and salivation.

Another ethereal oil, oil of mustard, 'attacked a man whose occupation required him to taste mustard seeds regularly. The teeth showed nine cavities with exposure of the naked pulp without any serious pain. The dental pulp seemed to be healthy, but was hypertrophied, and in the depth of the cavities were found carious masses. The extraction of the pulp was, however, painless. According
to the medical man in charge of the case
the lesions were undoubtedly due to oil
of mustard, or to substances which it con-
tained. Tobacco dust causes acute and chronic
gingivitis, principally in the middle of the
front teeth, a bitter taste in the mouth,
cough and irritation of the eyes. At the
end of a certain time immunity can be
acquired. Out of 158 tobacco workers,
Flescher found only 35 in whom the buccal
mucous membrane was unaffected. All
the others showed acute or chronic ginge-
vitis more or less serious.

LESIONS DURING INFECTIONS

Anthrax, in addition to its ordinary
manifestations, may sometimes cause a
pustule on the tongue developing as a
parenchymatous glossitis, in the course of
which the other symptoms of infection
are only slightly pronounced. As a local
complication oedema of the glottis has
been noted. The prognosis is inevitably
fatal in this case.

Glanders, actinomycosis, foot and mouth
disease, industrial syphilis of glass-workers
and musicians, and in general all in-
fec tious diseases with suppuration and
tuberculosis can attack the mouth or
adjoining parts during work. Koelsch
mentions a case of the transmission of
lupus by the glass-makers' blowpipe con-
fined to the vault of the palate after the
extraction of the second upper molar.
(See the different articles upon infection.)

Scurvy also, which is a disease due to
the absence of certain vitamins, and
attacks sailors and explorers, shows itself
by lesions of the skin and mucous mem-
branes which are situated especially in
the buccal cavity and particularly on the
gums.

PROPHYLAXIS

Among prophylactic measures, period-
cal inspection of the teeth by a
dentist should be placed first, especially
in trades which threaten to damage the
teeth (see article "Industrial Hygiene
(Workshops)"). The results obtained by
a similar medical inspection show the
value of the method. Leaflets and
spoken propaganda, beginning with
school life, among young persons and
parents will enable the object to be
attained in the near future.

LEGISLATION

Ulcerations of the mucous membra ne of
the mouth caused by dust are compul-
sorily notifiable in Holland (soap powder
factories), and are compensated as acci-
dents in Great Britain, Western Australia
and New South Wales. It is clear that
the poisoning and infections which are
the cause of lesions situated in the mouth
and teeth are notifiable and compensated
according to the regulations provided by
the different countries. (See the corres-
ponding articles.)

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Prof. F. Koelsch
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Nail-Works


The industry of screw-making is generally only a special branch of the industry of nail-making. The latter includes the manufacture of a great variety of nails, tacks, screws and horse-shoe nails and tackets, of different shapes and sizes.

Industrial Processes

Cleaning. — Iron rods used for making nails, on arriving from the rolling mill, are first subjected to the cleansing action of dilute sulphuric acid. The bundles of iron rods are plunged either by hand, by means of iron pincers, or mechanically by travelling cranes with immersion apparatus, into tanks lined with wood or lead, containing the acid solution. This operation has for its object the cleaning of the surface of the iron rod before subsequent operations.

Wire-drawing. — The iron rods, after being cleaned, are passed to the wire-drawing machine, where they are progressively lengthened and reduced in thickness by mechanical traction by being passed successively through draw holes, each of which is smaller than the last. Their calibre varies between 1 and 8 mm. On leaving the wire-drawing machine the wires are rolled up and placed in receptacles containing a lubricant mixture, consisting of acid, in order to continue the cleansing action, and of sulphate of copper, which is used as a preservative and also to prevent rust.

Liming. — This operation, which is not generally adopted, is an object of dispute among experts. It is intended to free the wires from excess of acid, to increase the preservative action and to facilitate the application of the knife in the cutting machines.

Nail-making. — The manufacture of all kinds of nails is always carried out in the cold state, the shape and particular calibre of the nails and tacks being produced by machinery only. These articles, which are very varied in shape and size, measure from 5 to 6 mm., for the smallest tin-tacks, up to 250 mm., passing through all the intermediate sizes.

The operations in question necessitate complicated machines and plenty of them. Average nail-works employ 300 to 400 machines, all in motion at the same time. Each of these machines is constructed in such a way that at each movement it cuts the iron wire, presses it to give it the shape and calibre required, and strikes it to shape the head.

The machines are at times driven with great rapidity. This rapidity varies between 65 and 525 movements a minute, which set in action the hammer striking on the end of the iron wire.

Nail machines are of two different types: machines with bow hammers, in which the striking hammer which makes the head is thrown back by a spring, sometimes made of wood; and pressure machines in which the hammer is fitted to a connecting rod joined to a cranked shaft.

In the first, the movement of the spring causes a percussion which is violent, sharp and sudden; in the second the shaping of the head is done by pressure, this being effected by a less violent blow, not so strong and consequently less noisy.

The bow-hammer machines were formerly used uniformly and generally in nail-making; pressure machines, which are more modern, are gradually, taking their place. Nevertheless, they seem to be always necessary for making convex-headed nails, for which a violent, sharp and considerable blow is indispensable. Pressure machines can only be used for simple flattening...
out of the ends of iron wire, as for nails with flat heads.

Apart from these general industrial processes, nail-making calls for certain special manipulation to meet special requirements.

(a) Whitening and polishing. — Finished small nails are mixed with sawdust and turned in a drum with polyhedral sides, actuated by machinery, in order to be cleaned, whitened and polished.

(b) Annealing. — Some wire is annealed before shaping. This process is intended to make the metal more malleable for making certain nails, such as nails for boots. This annealing is done in special gas or coal furnaces.

(c) Bluing. — Some nails are blued by heat in a special pear-shaped furnace with a rotary movement.

(d) Nails made from sheet iron. — Some nails of very small size are made from small bits of sheet iron which are cut up by machinery.

(e) Galvanising. — In some cases nails are galvanised in the following way. They are placed in drums worked by hand; a flux with an ammoniacal base is added, with sand to prevent sticking together, and solid lead and tin. The whole is heated to a temperature sufficient to melt the metals used for galvanising. The smoke, gases and fumes which are liberated are removed by exhaust ventilation. After heating, the nails are thrown into water, when ammoniacal fumes are given off.

(f) Screw-making. — Screw-making is really only finishing the rivets made at nail-works. The work is purely mechanical and carried out by machines which are very complicated and very accurate. Each rivet passes through two machines; the first is a cutting lathe, which turns the head of the screw and makes, by a stroke of a saw, the notch for the screwdriver. The second makes the thread on the screw, by means of a threading lathe, and finishes by making the point.

**Sources of Danger**

Quite apart from noise, which certainly constitutes a considerable nuisance in nail-works, the following operations must be noted as dangerous:

The cleaning process. — The workmen are subjected to fatiguing work when the rods are plunged by hand; they are inevitably exposed to the absorption of numerous acid fumes and vapours, and to burns which this caustic agent produces; they generally work in an atmosphere saturated with steam and with thick and opaque fumes, especially in cold weather. These workmen are exposed to chills, as the work is usually carried on in workshops which are mostly open to the air and exposed to continual draughts.

Wire-drawing and timing. — The men, in addition to being continually exposed to acid fumes, are also exposed to accidents peculiar to their work. The wire before passing through the draw holes is wound on a wooden reel; now, when the wire comes to the end of winding, it may be thrown up horizontally and strike the worker violently, so causing serious incised wounds; further, unskilful unwinding of the wire may twist it into what the workmen call "eights", which may fly out with a violent motion.

Dust is particularly abundant at the bluing of nails, both metallic dust and sawdust. When annealing, the CO given off exposes the workmen to poisoning and discomfort, while the possibility of lead poisoning in galvanising must also be borne in mind.

These various hazards are not, of course, peculiar to the industry of nail-making; but the noise deserves attention.

All the machines, the hammers of which strike the iron 60 to 600 times a minute, give rise to a complex of subintrant noises, of a violence and continuity which is not met with elsewhere. When, in addition to these noises, there are those of driving belts, of trucks running on rails, of drums for cleaning and bluing, and of the enforced shouting of conversation, some idea may be gathered of the importance of this occupational hazard from the point of view of the workers' health.

If an attempt is made to analyse this complex of noises, the following characteristics will be noted. When standing facing a machine with a wooden spring hammer, the hammer is seen and heard to strike the end of the wire in order to flatten the head; the blow is violent and sharp, without resonance; the hammer falls with a deadened thud and causes a noise, rather than a sound, absolutely unmusical, without timbre and without subsequent air vibrations; the noise is violent when produced, but muffled at once by the flatness of the head; a second noise follows the first immediately; the different noises repeat them-
selves on these machines at the rate of about 60 to 200 times a minute. The pressing machines, acting by the intermediary of a crank on a shaft, drive hammers which combine in their action blows and pressure. The noise is not so sharp or harsh; it is softer and more delicate; it has the same characteristics of suddenness, but its intensity is much attenuated, and may be 80 per cent. less than that of the machines with the wooden spring bow hammer.

The degree of noise varies with the variety of machine: heavy hammers emit a deep note, beating at from 60 to 200 times a minute; machines for small nails and tacks make a noise which is much shriller and less violent, but much more frequent (up to 550 a minute).

To these noises is added a particular tremor felt in the ground, which actually vibrates close to the large machines, and seems to shake after each blow.

The effect of these noises is to cause hardness of hearing; and an enquiry made by Langelez shows that among a group of men, working regularly and irregularly in the noise, 15 per cent. were normal, while 86.5 were abnormal from the single point of view of auditory acuity. This enquiry covered the whole personnel of a factory.

The proportion of those affected with deafness according to age and the number of years of work is as follows:

### TABLE A. — AGE GROUPS

<table>
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<th>14-20 years</th>
<th>20-30 years</th>
<th>30-40 years</th>
<th>40-50 years</th>
<th>Over 50 years</th>
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<td></td>
</tr>
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<td>Normal</td>
<td>4</td>
<td>5</td>
<td>1</td>
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</tr>
<tr>
<td>Abnormal</td>
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<td>18</td>
<td>8</td>
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<td>Irregular work in noise:</td>
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<tr>
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</tr>
<tr>
<td>Abnormal</td>
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<td>3</td>
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<td>Work apart from noise:</td>
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<td>14</td>
<td>6</td>
<td>3</td>
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<td>—</td>
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<tr>
<td>Abnormal</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>—</td>
<td>5</td>
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</table>

### TABLE B. — DURATION OF WORK

<table>
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<tr>
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<th>Less than 5 years</th>
<th>5-10 years</th>
<th>10-20 years</th>
<th>Over 20 years</th>
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<td>Work in noise:</td>
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</tr>
<tr>
<td>Normal</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Abnormal</td>
<td>7</td>
<td>8</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Irregular work in noise:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Normal</td>
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<td>—</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Abnormal</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

In another enquiry, dealing with workmen belonging to different works in a Belgian town which specialises in nail-making, deafness was investigated by means of the Weber tests with tuning fork on the skull, of Bonnier tests with tuning fork on the patella, of Rinne tests with tuning fork on the mastoid, of Gelle tests with tuning fork on the vertex, and by means of those of Gradengio and of Galton with the whispered voice. Examination of the results obtained by these different tests shows clearly a predominance of disorders of the transmission apparatus over those of the receiving apparatus.

The appearance of lessened acuity occurs very early: between twenty and thirty years, 5 normal for 13 abnormal: between thirty and forty, 1 normal for 18 abnormal. Some workers are conscious of this infirmity, but others are quite unconscious of it, affirming that they hear perfectly well, even though they do not hear the tick of a watch at 10 cm. In these cases lip-reading becomes a characteristic habit.

**Prophylaxis**

On this subject, see article "Noises". As regards nail-works, in particular, it...
Naphthaline


**TECHNICAL DATA**

Naphthaline (C₁₀H₈), discovered by Garden (1819) and Kitt (1821) in coal tar, abounds in tars of high temperature (gas works and coke works). Naphthaline obtained by fractional distillation (between 170° and 300° C.) of tar, or by redistillation of the residues of the oils from which phenic acid has been extracted, is separated from the crude oils by cooling in large tanks where it crystallises. The naphthaline is purified by pressure in a hot state in order to eliminate the oils, then washed in sulphuric acid and soda and finally distilled. Special presses are used for making balls of naphthaline.

Pure naphthaline obtained by sublimation is in the form of brilliant sheets. It melts at 79.6° C. and boils at 218° C. Insoluble in cold water, slightly soluble in boiling water, very soluble in ether, it volatilises even at an ordinary temperature and is easily drawn off by steam.

Naphthaline is used in large quantities in the preparation of various colouring agents, phthalic acid, lamp black, varnishes, grease for greasing vehicles, as an antiseptic, etc.; mixed with camphor it serves for the preparation of non-inflammable celluloïd and is less explosive.

Amongst the most important derivatives of naphthaline are the a and the b-naphthylamine (see that article) and the a-chloronaphthaline (C₁₀H₈Cl) obtained by making chloride act on boiling naphthaline, or in denitrating a-naphthylamine and subsequently decomposing the compound obtained by means of copper chloride. The liquid in question, the density of which is 1:1938, boils at 283° C., and is used in the preparation of various chloro-sulphonic acids and of naphthaline green.

Perchloronaphthaline, used for impregnation of materials and as a substitutive for resins and caoutchouc, is a chlorinated naphthaline ("Perna"), which takes the form of a brownish black mass. It is soluble in lipoids and readily volatile.

The nitro-derivatives of naphthaline (molecules b-, tri- and tetra-nitronaphthalines) are very much used in the explosive and colouring matter industries.

The a-naphthol (C₁₀H₁₂O) prepared by starting from a-naphthylamine or from the a-naphthalenesulphonate of sodium, takes the form of brilliant monocalinous needles. It melts at 94° C. and boils at 270° C. It is used in the manufacture of azo-compounds, serving as colouring agents.

The b-naphthol is obtained industrially exclusively from b-naphthalenesulphonate of sodium. This product, which takes the form of brilliant white crystals, melts at 123° C. and boils at 285° C. It sublimes easily and distils with super-heated steam. It is used in the preparation of various numerous colours and in medicine. With salicylic acid it is used for the preparation of mixture applied to cotton materials with a view to rendering them impermeable and preserving them from parasites. Its methyl and ethyl ethers are used as "fruit essences".

Naphthaline constitutes the most advanced stage of the thermal transformation of non-saturated carbides. This naphthenic nucleus very readily absorbs hydrogen. The process, known even before the war, has been utilised successfully in Germany for at least twenty years.

Hydrogenation of cyclic hydrocarbides is applied especially during the manufacture of volatile solvents and liquid carburettants. It is particularly the hydrogenation of naphthaline which has provided a compound of great importance: tetraline used as a carburettant in the place of petrol (see the articles "Solvents" and "Strap").

The naphthaline is first purified by means of metals by utilising sodium or powdered metals. In this way it is freed from all its sulphur. If thereafter undergoes a method adopted successfully in the hydrogenation of oils and is transferred totally into a tetrahydrogenated derivative (tetraline). If hydrogenation is continued for a longer time there is obtained a decahydrogenated product (decaline).

The mercuric sulphate has been used for some years as a catalyst of
oxidation of naphthaline, in order to transform it with the aid of fuming sulphuric acid into ortho-phthalic di-oxide. In this branch of industrial manufacture, which has acquired a remarkable extension, there is obtained a compound which is at the basis of the method of preparation of synthetic indigo.

Pathology

According to far from recent observations made by Grandhomme (1893-1895) (factory at Hoechst s/M), naphthaline was said not to exert harmful action on the workers engaged in preparing or handling it. Modern experts, on the contrary, incline to the view that this harmfulness is by no means absolute. There has been reported in fact an irritant action of naphthaline fumes and even of mineral oils containing traces of naphthaline (Eisner) on the skin with production of red spots, papular eczema (Bourguignon) and of acne (Brussolle).

Dermatitis, usually localised on the uncovered part of the skin, may in certain cases, if the patient is hypersensitive, become generalised (Poluny) with anhydroses and an uncomfortable sensation of heat; cutaneous affections have been caused by products containing naphthaline even in very small quantities (1-1½ per cent.) (case of Eisner).

Amongst persons predisposed the irritant action of naphthaline is manifested by cheloids (Patschke and Plaut), but more frequently by chronic eczema (Pinkus). Handling of fur impregnated with naphthaline has caused, in the case of a strong man, temporary oedema of the face, hands, feet and abdominal region. Some erythrocytes were found in the urine.

Ocular troubles have also been reported: superficial punctated or vesicular spots on the cornea (Grünwald) which may even develop into ulceration (Uliman); chorioretinitis amongst workers engaged in sorting skins preserved with naphthaline with other workers in gas factories engaged in the naphthaline department (Van den Hoeve 1906).

A doubtful case of cataract1 has been notified by Caspar, as well as a case of bi-lateral optic neuritis, which was cured after four to five weeks, affecting a worker exposed for several weeks to the action of naphthaline fumes (Koelsch). Labbé and Lavagna have noted modifications of the acid-basic equilibrium of the fluids of the eye, and Lienhart in 1923 engaged in a study of hereditary ocular troubles amongst rabbits induced by naphthalinic poisoning.

Loewy and Grünwald met with catarhal irritation of the upper respiratory passages. Although naphthaline may also cause symptoms of general poisoning (headache, nausea, vertigo, weakness of the legs, unsteady gait, etc.) serious forms would only appear to occur exceptionally in industry. Naphthaline must, however, be considered as a fairly dangerous poison, for Prochownik reports a fatal case due to a dose of 0.25 grm. in a child of six years (methaemoglobinæmia, paralysis of the heart and respiratory centres). In an adult serious poisoning is manifested by tenesmus, jaundice, toxic nephritis, with haematuria and enlargement of the spleen. Experiment has also confirmed diminution of the red blood cells (Von Jodel, M. Loewy and Heine).

In 1926 a worker, in applying hot asphalt to a plank, diluted it by means of a product known under a fancy name. The mixture liberated abundant fumes of naphthaline. In the following weeks the worker became pale, anaemic, suffered from cardiac weakness and pernicious anaemia, which rapidly developed towards a fatal issue (Heubner).

A case of cancer of the bladder was reported in January in 1921 in Germany as affecting a worker who had for long years been in contact with naphthaline. Another case was encountered in Great Britain, being that of a worker who for sixteen years had worked with β-naphthol and for seventeen years had been engaged in nitration of naphthaline.

Amongst the chlorinated derivatives it is perchloronaphthaline which is responsible for the most serious effects on health. In 1918 Wauer described under the name of Perna disease (Pernakrankheit) the cutaneous troubles studied later by Koelsch and especially by Teley and due particularly to the fumes of the molten mass or to sublimated dusts. The affection in question is represented by cutaneous irritation and particularly by forms of folliculitis and of acne, at times of a very serious nature. The product may also exert a general action (see above). The injuries affect workers occupied in the preparation of perchloronaphthaline or in impregnation of materials, papers, etc., with the latter, as well as individuals only coming into indirect contact with the product.

1 Cataract due to the action of naphthaline has also been produced in an animal.
The cutaneous lesion is mostly localised on the uncovered parts of the body and zones of "friction" (Koelsch). Teleky has described the characteristic appearance of this affection as a superficial eruption localised on the cheeks, forehead and chin or in slight forms consisting of small narrow zones on the temples, cheeks, back of the neck and behind the ears, formed by numerous comedons and small yellowish-white nodules, probably constituted by small sebaceous cysts.

The gravity of the injuries would appear to depend on the halogen content of the product, for the more chlorine there is in the perchloronaphthalene used, the more marked are the clinical symptoms (Teleky). In fact, a very considerable improvement in the health of workers has been noted since the chlorine content of the mass has been changed from 35-40 per cent. to 7-8 per cent. On the other hand, individual predisposition would appear to provide an explanation of receptivity in regard to this disease, which is nevertheless of fairly frequent incidence. During the war, out of 90 workers exposed during nine months to the action of the toxic products, there occurred 50 cases of disease, and Koelsch estimates at 50 per cent. the average incidence of cutaneous affections.

In a group of 150 to 280 workers (including certain individuals very little exposed) examined by Teleky in 1926, there were recorded 33 cases of serious poisoning, 37 of average forms, 38 of slight forms and 62 in which mere traces of the harmful agent were noted. Experimental ingestion of Pernap causes anorexia to the point of preventing all consumption of food and leading to death by inanition. At the autopsy there were found lesions of the liver, reflecting the acute yellow atrophy. However, cutaneous troubles resembling chloric acne were not noted amongst the animals (Lehmann).

The various nitro-derivatives of naphthalene are said to exert a very slight toxic action (Koelsch) and it is for this reason that it has been suggested that they should be deleted from the list of industrial poisonings. Animal experiment appears to confirm this view.

The a-nitronaphthalene \((C_9H_7NO_2)\), which is only one of the two mononitro-derivatives of any importance from an industrial point of view is said to cause forms of conjunctivitis, a sensation of burning in the eyes amongst workers exposed to the irritant action of its dusts or fumes. In the clinic of Fuchs, Hanke and Frank were able to note slight cases with a chronic development of opacity of the cornea due to spots located on the middle region of the cornea. These spots of oval form, which, however, did not reach the limbus, consisted of a group of small vesicules on a greenish-grey background. The most important symptom was a slow, fairly marked diminution of sight.

On the other hand, the two cases described by Silex (1901) were characterised by a acute violent form with perikeratinous congestion reaching the middle layer of the substantia propria. Opacity in these cases extended even to the peripheral extremity of the cornea.

It is, however, necessary to insist on the fact that these cases, very few in number, were but the expression of neglected predisposition as affecting certain individuals exposed to the action of nitronaphthalene fumes or dust. Animal experiment has proved that exposure to the fumes in question for a period of eight hours by application of the toxic substance to the cornea of animals does not cause the opacity noted in the case of certain human beings (Lewin and Guillery, who recall the fact that very often experimental research fails to reproduce the clinical picture noted amongst human beings).

The observations in question are, moreover, of not very recent date, and in the last fifteen years no cases of keratitis due to nitro-derivatives of naphthalene have been reported (Koelsch). In conclusion, it should be recalled that these products have been said to cause formation of met-haemoglobin amongst animals (Röhl, 1890).

The a- and b-naphthols are considered by Lehmann as doubtful industrial poisons. American literature contains, however, evidence of one case of poisoning with fatal issue. Cases of eczema were reported as well as brownish pigmentation and epithelial desquamation of the cornea, cephalalgia and vomiting amongst workers exposed (Koelsch). For details relative to cancer of the bladder, see above.

**Hygiene**

The distillation room and the melting room in the manufacture of naphthalene should be separated, and likewise the store room should be separated from the melting room by means of doors which can be hermetically closed. Apparatus and piping should be airtight and withdrawal of gases liberated during the running off
of heavy oils should be perfect from a technical point of view (Grunwald). Mineral oils free from traces of naphthaline should be used.

The workers should be protected as well as possible against the action of harmful dusts and fumes, and rigorous personal cleanliness should be insisted on, supplemented by the provision of working clothes. Dusting of the skin with inert powders should be recommended prior to the commencement of work. There should be careful selection of workers, with a view to eliminating predisposed individuals. Periodical examination of urine should be effected in order to detect the presence of erythrocytes.

**Legislation**

Legislation is similar to that for the chemical industry in general and for nitro- and amido-derivatives in particular (see those articles). In Germany only chronic cutaneous or chronic recurring affections due to naphthaline can be compensated where naphthaline may be included amongst "allied substances" comprised under No. 13 of the list annexed to the Order dealing with extension of accident insurance to occupational diseases of 11 February 1929.

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**Naphthylamine**

*(Aminonaphthalene)*

The naphthylamines, important from a technical point of view and characterised by the different positions of the amino group, are: the \( x \) naphthylamine \( (C_8H_7NH) \), of which the commercial product is found on the market in brilliant grey flakes, of a slightly reddish-brown tint and having a distinctly foecal odour. The pure product melts at 50°C. and boils at 300.8°C. The \( \beta \) naphthylamine occurs in brilliant colourless flakes, melting at 115°C. and boiling at 294°C. Only soluble in water with difficulty, these two compounds are easily soluble in alcohol and ether and can be carried away by steam.

**Technical Uses**

The manufacture and use of naphthylamine only take place in the aniline colour industry, where \( x \) naphthylamine is obtained by reducing \( x \) nitronaphthalene with iron and hydrochloric acid, as is the case with aniline. The apparatus used is not unlike that used in the manufacture of aniline (see that article): at the same time, the products used for the reactions and the final products are less readily carried away by steam.

It is therefore not necessary to furnish the reducing apparatus with an ascending cooling apparatus. After the gradual introduction of dry mono-nitronaphthalene into the mixture of iron filings and acid, heated by direct steam, the temperature is regulated in such a way as to remain within the desired limits. Once the reaction is over, the molten naphthylamine is decanted and the muddy deposit is rendered alkaline with lime. After cooling it is subjected to distillation with superheated steam at 250°C in order to recover the naphthylamine and condensed steam together.

The crude naphthylamine is solidified outside the receptacle in a blackish crystalline mass, is separated from the water, mechanically remelted, and distilled under a vacuum to obtain the pure product. This takes the form of an oil, as clear as water, which, when directed into moulds, solidifies in a white mass; this is crushed before it is used in the preparation of azotic colours.

\( \beta \) naphthylamine is only prepared by heating \( \beta \) naphthol in an autoclave at 150°C. with dry sal ammoniac or strong ammoniacal solution and sulphite of ammonia. The mass, when slightly cooled, is poured on to a filter, aspirated, washed with a dilute solution of caustic soda, and dissolved in dilute hydrochloric acid. It is then filtered to remove insoluble impurities and the sulphate of \( \beta \) naphthylamine is precipitated out of the solution by means of Glauber salts. If the product is not utilised in this form, the base liberated by an alkali is distilled afresh in a vacuum and the resultant crystallised product is ground down.

The two naphthylamines are almost exclusively used in the manufacture of azo-colouring matter, partly for their conversion into the corresponding sulphonic acids. To a lesser ex-
tent they are used in the form of alkyl and aryl compounds.

x naphthylamine is also used in the preparation of naphthol (when heated in an autoclave with sulphuric acid to 200° C.) and in photography for obtaining bluish tones.

Among the derivatives obtained as intermediate products, the most important are the sulphonylic acids. They are prepared only partly from bases (obtained also by heating the sulphonylic acids of naphthol with ammonia or by reducing the sulphonylic acids of nitro-naphthalene). They are generally obtained by the process of roasting, especially the sulphonylic acid of x naphthylamine (naphthionic acid) (see article "Aniline"); the acid sulphate of x naphthylamine is heated to 180-200° C. with the addition of carbonates to improve the output; solution proceeds; it is extracted from the mass by means of a soda solution, and the carbonate of soda formed in the filtered solution is separated out by crystallisation. The separation of the isomers which are formed is of no interest, since the sulphonylic acids are perfectly harmless (see also article "Aniline").

**Sources of Danger**

(a) In the manufacture of x naphthylamine: there is a slight danger of evolution of fumes while reduction is being effected; this is greater during distillation and emptying of the raw product and of the final product.

In the manufacture of β naphthylamine: evolution of steam containing naphthylamine only takes place if the autoclave leaks.

Distillation of the two products under a vacuum does not present any danger, as fumes are only evolved in the course of emptying receptacles.

(b) In their use: some danger from dust occurs during grinding and packing of the product, while placing the substances in the vats and in the course of the manufacture of the azo colouring matters.

**Toxic Action**

The two naphthylamines are toxic (but not their sulphonylic acids). The acute symptoms, however, of this toxic action have not been observed up to the present, except experimentally in animals. The principal channel of entrance of the poison into the organism seems to be, from the point of view of industrial practice, the respiratory organs (fumes and dust); unjured skin comes second.

The toxic effects resemble those produced by other aromatic monoamines and particularly by aniline.

According to experiments made by Pittini on rabbits, in addition to generalised paralysis, x naphthylamine causes haemorrhagic diarrhoea (fetal dose: 0.4 grm. per kg.). According to researches made by Engel on dogs, the two naphthylamines produce changes in the haemoglobin (methaemoglobinamaia), with marked cyanosis.

β naphthylamine causes the destruction of the red blood cells with haemoglobinuria and, marked secondary anaemia, generalised paralysis and sometimes, even with small doses, haemorrhages into the bladder and marked ischuria. The fatal dose of β naphthylamine is 0.5 grm. per kg.

Although, in fact, the naphthylamines are hardly less poisonous than aniline, no acute intoxication symptoms of characteristic poisoning in man have been observed so far.

Looked at in this way, the manufacture and industrial use of naphthylamine does not represent any considerable risk to the general health of the workman. On the other hand, those who handle naphthylamine are exposed to great risk of damage to the bladder, haemorrhage, papillomata and cancer of the bladder. Of all the aromatic amido derivatives, it seems that it is particularly the β naphthylamine which induces the greatest number of these maladies, especially among persons employed in the manufacture of β naphthylamine and of the sulphonylic acid of x naphthylamine and not in the course of their use.

According to Engel, β naphthylamine, which undergoes oxidation in the organism, is generally eliminated by the urine in the form of sulphuric acid of β amido x naphthol and of glycuronic acid. Unconverted β naphthylamine is only found in traces; x naphthylamine, on the other hand, is said to be largely eliminated untransformed.

In Germany a case of haematuria was reported. In 1912 in a workman manipulating β naphthylamine; in 1913 (Bavaria), four cases of tumours of the bladder; three of which were caused by naphthylamine (the workmen, however, had also come into contact with benzidine, chloro-aniline and chloro-toluidine); during the period 1914-1918 among thirteen cases of tumours of the bladder, five, in the Northern Palatinate, were due to β naphthylamine; in 1921, one case was
reported in the district of Wiesbaden and a fatal case in another district from \( \beta \) naphthylamine; in 1922, a case in Bavaria; in 1923-1924 nine cases, of which three were fatal, in Bavaria from naphthylamine and aniline in 1926, four cases.

According to Hamilton, \( x \) naphthylamine does not appear to give rise to serious lesions. At the same time, one of the first cases described in the United States was that reported by Apfelbach in 1913. It had reference to a case of cyanosis induced by an amido compound. Another case has been reported from a colour factory affecting a worker handling \( x \) naphthylamine.

According to the same expert, the \( \beta \) naphthylamine was the more toxic, as the workmen who manipulated it in an American factory showed symptoms of cyanosis and poliakuriia. On the other hand, this same factory never had trouble with the \( x \) compound.

In Great Britain, Wignall, in a report presented to the Industrial Hygiene Section of the British Medical Association (Manchester, 1929) brought to light the fact that, in an aniline colour factory, of which he was then works surgeon, eight cases of urinary trouble among workers, all ending fatally, had been reported between 1880 and 1900, but of these no precise details existed. He had seen three of them.

Since 1900 the factory has manufactured a great deal of \( x \) naphthylamine without the use of arsenic; the number of workmen employed varied from 100 to 200.

In 1902 Dearden reported acute cases of anilism among workmen employed on aniline black. From the year 1910 onwards Wignall had been able to follow very closely the cases occurring amongst workmen in the factory. He then knew of three fatal cases of tumours of the bladder caused by \( x \) naphthylamine and had knowledge of other cases which he had not been able to confirm. Since 1918 the number of cases occurring among workmen coming into contact with \( x \) naphthylamine was four, two of whom were fifty-six years old, had been employed in the factory for thirty years, and had been twice operated on for tumours of the bladder; one is dead and the other, tuberculous, is under treatment. The third workman, aged fifty-eight, with a record of employment of twenty years, was operated on once and has died of cancer of the bladder. The fourth, aged fifty-four, who was operated on once for tumour of the bladder, is at the present time under treatment.

The precautionary measures adopted in the factory have certainly improved the situation and enable detection at an early stage of bladder lesions. In the experience of Wignall, \( x \) naphthylamine cannot ever be considered as the cause of cyanosis, dermatitis, irritation of the eyes, nose, throat or larynx.

He insists also on the fact of the difficulty of affirming whether naphthylamine ought to be considered as the most important factor in the development of bladder lesions, because the workmen have been employed in so many different departments from time to time, where they have been exposed to the injurious action of products other than naphthylamine (see also article: "Industrial Diseases: Urogenital System").

**Detection in the Urine**

(a) \( x \) naphthylamine. — Acidify the urine in the cold state with hydrochloric acid and add a few drops of solution of nitrite of soda and a solution of \( 3-5\text{-7} \) phenylamidonaphthol, a violet colour is obtained, which is capable of dyeing cotton.

(b) \( \beta \) naphthylamine. — Acidify the urine with hydrochloric acid; let it boil rapidly (to saponify the associated compounds). Allow it to cool; add ammonia and agitate. A violet coloration is obtained with a dark violet precipitate.

**Diagnosis**

The early detection of bladder trouble demands a regular periodic examination of the urine for the presence of red blood cells; if the evidence is positive, the worker should be examined cystoscopically. Bladder tenesmus and haematuria may quite easily be the signs of a mild disease (haemorrhagic cystitis), but they are often also the first symptom of cancer.

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1 At the Congress of the Association of Surgeons of the Middle Rhine (held at Tübingen, 8-9 June 1929), Schaer, of Basle, made a communication on the subject of the experimental production of cancer of the bladder. After inhalations of very small doses of naphthylamine lasting over a number of months, he was able to obtain positive results with rabbits. As a matter of fact, Schaer was able to show epithelial alterations of the most different kinds, including the formation of papillomata and carcinoma of the mucous membrane of the bladder. In the course of the discussion at Ludwigshafen, brought into prominence the fact that, in the manufacture of aniline colours, tumours of the bladder have been much more rarely met with since the manufacture and use of naphthylamine has been given up.
of the bladder which is already inoperable. With a view to the prevention of haemorrhages of the bladder, efforts have been made to detect periodically in the urine naphthylamine, by means of diazotisation and combination with the sulphonamic acid of phenylamidonapthol, but this seems to be a measure of doubtful utility.

HYGIENE

Although the toxicity of the naphthylamines, from the industrial point of view, is manifestly feeble, the risks of bladder lesions for workmen inhaling quantities of naphthylamine over a long time, however weak they may be, demand a meticulous health organisation in the processes of work.

All evolution of vapour in the room should be prevented during the preparation and distillation of the pure crude products; and use should be made of tightly sealed apparatus provided with localised exhaust ventilation. This last measure should be similarly adopted during emptying of the distillation apparatus, as well as in the preparation of the sulphonamic acids.

All evolution of dust should be avoided by carrying on grinding processes in a closed apparatus and by emptying such apparatus and packing the ground products subject to adequate precautions. Where necessary the workers should be supplied with respirators. In order to avoid scattering dust on the floor or its escape into the air, several factories place flat tubs filled with water and covered with an iron grill under the casks, which is filled with water and covered with an iron grill under the casks, which is a very effective precaution. Localised ventilation, smooth and impermeable floors easy to clean, and working clothes fitting closely round the neck and wrists and washed and changed frequently should be provided. Periodic medical examination, always completed by regular analysis of the urine, should be arranged for.

LEGISLATION

For statutory regulations on the installation and equipment of these factories, see article "Nitro-Amido Derivatives", as well as for the statutory provisions as to notification and compensation of diseases due to the products in question.

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Dr. H. Engel
(Berlin).

Native Labour (Hygiene)


Measures of hygiene to protect the health of native workers are distinguished from those laid down in ordinary industries by the fact that in the case of the latter the attention of the health expert is concentrated specially on the factory and on the industrial work carried on in it, whereas as regards the former, the hygienic measures are rather general in character.

The opinion has been expressed that it is more accurate to speak of accidents only in regard to native labour, the use of the term "occupational disease", or illness caused by work, being inappropriate, seeing that most of the activities engaged in by natives take place in the open under very healthy conditions (Merlin).

However, even leaving out of account work in mines and other industrial concerns with risks similar to those met with in temperate climates, native workers are frequently, if not always, subject to conditions forming an extraordinary contrast to those of their normal life. These conditions involve considerable distress, even for individuals in perfect health, from the moment they leave their homes until they are free to quit the workplaces or plantations.

In the colonies, as is well known, the villages from which these workers are drawn are often at a considerable distance from the place where they work and the journey exposes them to certain dangers. In some cases, they are recruited from regions presenting conditions of climate and of life radically different from those in which they are called upon to work. Thus, for example, the natives of the Rand Mines (South Africa) are recruited partly from certain Bantu tribes or from
parts of Mozambique south of 22° S. latitude (Orenstein).

Very often during the journey a number of those recruited break down under the hardships endured, for, as is stated in the Annual Report for 1925 of the Tanganyika Territory, rest-houses are few in number or non-existent and the food of the workers differs greatly from that to which they have been accustomed at home. Further, the workers travel under conditions devoid of adequate hygienic measures and are exposed to various maladies.

The risks run are much greater for races not in possession of immunity against certain infections. These workers, on arriving at their destination, may thus be in a miserable condition and incapable of carrying out the work assigned to them, which they generally find difficult owing to their inexperience. Those who arrive free from disease are nevertheless weakened by fatigue and by the privations undergone on the journey, and are ready to fall victims to any disease raging in the district, such as malaria, yellow fever, sleeping sickness, etc.

For these reasons the healthy worker is exposed to a risk in direct relation to his employment, a fact which has been recognised on various occasions, amongst others, at the National Colonial Congress at Brussels in 1924. For example, on the subject of sleeping sickness it has been said that one of the causes of the spread of this disease is "certainly the harvesting in contaminated regions of certain natural products: coconuts, copal, rubber, etc. This harvesting causes a more intense circulation of the population and subjects it to conditions of life which diminish the resistance of the body to disease ".

Colonial authorities and employers do take into consideration the importance of hygiene in dealing with native labour because of its effect on output (Noel Bernard, Heckenroth) and an ever-increasing attention is being paid to this aspect of the problem. At the same time, much progress has still to be made, and in order to arrive at a satisfactory situation in regard to the matter, attention must be paid, from the hygienic point of view, to general as well as particular aspects of the employment of native labour and to the procedures to be adopted before and during employment.

Up to the present, information on the subject of native labour only exists with regards to certain industries: gold mining, diamond mining, tea and coffee plantations. Apart from these spheres of employment only a limited amount of data is available as to food and lodging, but such information is really of no value in regard to morbidity and mortality. This state of affairs is comprehensible, bearing in mind the rudimentary state of the sanitary and medical organisation in the countries in question, and the difficulties which it encounters.

Obviously, resistance to exhaustion and disease is increased if food is sufficient and healthy. The colonial sanitary authorities have from the outset paid particular attention to the rations suitable for native labourers.

In the Belgian Congo, the authorities of the province of Katanga have drawn up regulations as to the hygiene and safety of workers (1927) which lay down the weekly ration for workers in industrial, agricultural and commercial enterprises, both public and private. This ration gives as a minimum: manioc flour, 1,200 grm.; beans, 500 grm.; ground-nuts, 500 grm.; vegetables or fruit, 1,000 grm.; fresh meat, 1,400 grm.; salt, 105 grm.

In this ration, 1 kg. of maize or rice flour, 1,20 kg. of sorghum flour, or 1,10 kg. of millet flour (eleusine) can be substituted for the manioc flour.

The haricot beans can be replaced by equal quantities of peas or lentils; the ground-nuts can be replaced by 300 grm. of palm-oil or any other animal or vegetable fat.

As regards the fresh meat, 1 kg. can be replaced by 1 kg. of chilled or frozen meat or fresh fish, or by 600 grm. of preserved meat or 500 grm. of smoked meat or 800 grm. of dried fish. In any case, the meat must not contain more than 20 per cent. bone, and only in cases where it is impossible to procure fresh meat is chilled or frozen or preserved meat or fresh or dried fish to be substituted for it.

Still other modifications can be allowed, but only with the written permission of the medical inspector supervising the workers.

No worker is allowed to give up any portion of his ration and it must be delivered in kind, the corresponding value in money not being authorised except in the case of those workers in receipt of a daily wage of at least 4s.

Another example of the type of food supplied is shown by the ration furnished to Indian workers in the Federated Malay States. This ration comprises: rice, 18 tahils; fresh vegetables, 6; fish or meat, 4, or dhal, 5;
The workers also receive hot coffee or tea in the morning before starting work.

In the French mandated territories there are sometimes considerable differences in the quantity of foods allowed to workpeople from two adjacent countries and subject to exactly analogous conditions of existence and climate. Thus, for example, the daily ration of food for workers in Togoland is entirely different from that for the Cameroons, as will appear from the following table:

<table>
<thead>
<tr>
<th>Daily ration of food in Togoland</th>
<th>Grm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Fresh fish</td>
<td>400</td>
</tr>
<tr>
<td>or dried fish</td>
<td>300</td>
</tr>
<tr>
<td>or meat</td>
<td>400</td>
</tr>
<tr>
<td>Millet or maize</td>
<td>1,000</td>
</tr>
<tr>
<td>or maize flour</td>
<td>900</td>
</tr>
<tr>
<td>or millet flour</td>
<td>600</td>
</tr>
<tr>
<td>or yam</td>
<td>900</td>
</tr>
<tr>
<td>or manioc</td>
<td>900</td>
</tr>
<tr>
<td>or undecorticated rice</td>
<td>500</td>
</tr>
<tr>
<td>or decorticated rice</td>
<td>1,000</td>
</tr>
<tr>
<td>C. Palm oil</td>
<td>40</td>
</tr>
<tr>
<td>D. Salt</td>
<td>30</td>
</tr>
<tr>
<td>E. Allspice</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Daily ration of food in the Camerouns</th>
<th>Grm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Salt fish</td>
<td>130</td>
</tr>
<tr>
<td>or fresh meat</td>
<td>200</td>
</tr>
<tr>
<td>Maize flour</td>
<td>650</td>
</tr>
<tr>
<td>or millet flour</td>
<td>650</td>
</tr>
<tr>
<td>or maize heads</td>
<td>3,000</td>
</tr>
<tr>
<td>or manioc</td>
<td>3,000</td>
</tr>
<tr>
<td>or manioc</td>
<td>3,000</td>
</tr>
<tr>
<td>or vegetables</td>
<td>500</td>
</tr>
<tr>
<td>or decorticated rice</td>
<td>650</td>
</tr>
<tr>
<td>C. Palm oil</td>
<td>50</td>
</tr>
<tr>
<td>D. Salt</td>
<td>90</td>
</tr>
</tbody>
</table>

All these recommendations would be extremely useful were it possible to apply them in full. The difficulty in doing so makes the question of the insufficiency of the diet of the natives one of general import and not particularly a question affecting the workers only. The Academy of Colonial Sciences in France has called attention to the fact that of all the causes leading to depopulation of the colonies, this problem of alimentation was the chief one, and it expressed the view that "under-nourishment, which is very frequent, must be looked upon as an essential factor in connection with mortality, and the low birth-rate brought about by epidemics, bad conditions of living and lack of hygiene among the natives, syphilis, alcoholism, etc. In order to remedy this deficiency in food which is so prevalent, the Academy lays down as a necessity the fullest possible development in all the colonies of the cultivation of foodstuffs, of fishing and of stock-rearing, coupled with the pursuit of a rational, policy relative to the education and reconstitution of the native races." (Roubaud)

So far as clothing is concerned, sufficient attention has not yet been paid to this problem as it affects the native workers, although it is certain that if the negroes were more suitably clothed, they would be in a better position to resist the most widespread maladies, especially pneumonia, the high incidence of which amongst the natives is partly due to the fact that they are insufficiently clad (National Colonial Congress, Brussels, 1924).

The reason why the black races do not dress like Europeans is due to their poverty, which prevents them from buying other clothes than those which they have always worn. A first step towards providing them with a suitable dress has been taken in the Belgian Congo, where the legal requirements provide that each individual who is recruited must be supplied with a blanket of mixed cotton and wool; in West Africa, in Togoland and the Cameroons, similar provision is made, the native worker receiving a large, heavy and thick blanket for the duration of his contract. The conditions are better in Madagascar, where men who are sent to work at altitudes exceeding 800 metres have warm clothing given to them on their arrival. In Oceania the workers have the right to two "changes" yearly, each change including a blanket, two shirts, two pairs of cotton trousers and a head kerchief.

The question of the native worker's dress demands an equitable solution. The clothing with which he is provided becomes worn out while he is at work and it is only just that it should be replaced (Heckenroth).

In the province of Katanga in the Belgian Congo, the construction of camps and rest-houses is regulated in detail by the Order of 4 October 1927, No. 28, on the hygiene and safety of workers. The quarters of native workers employed outside the cities take the form of camps, the construction of which in certain cases is undertaken by the employer. He is obliged to submit the detailed plans of the situa-
tion of the camp and of the nature of the dwellings and annexes to the approval of a medical man. The site has to be kept in good condition, as have also the quarters and their annexes. The ground must have a natural fall so as to allow the water to run off; it must be provided with a supply of drinking water and water for washing and for the preparation of food. The ground must also be cleared of brushwood to at least 25 m. from the outside buildings. So far as dwellings are concerned, special measures are laid down as to their durability and situation according as to whether they are built of straw, concrete, sheet-iron, dried or baked bricks, or stone. In the absence of a more perfect installation, the use of a system known as “fosse de fumigation” may be employed for latrines.

In the absence of a more perfect installation, the use of a system known as “fosse de fumigation” may be employed for latrines. Finally, the camps must be provided with suitable washing accommodation and incinerators. The incinerators and the latrines must be at a distance of at least 30 m. from any living quarters. When workers have to be recruited from distant regions, rest-houses must be constructed, which may not be more than 30 km. distant from one another if the workpeople travel on foot. Every rest-house must comprise quarters for the workpeople corresponding to the maximum number to be housed, lodging for the staff, a store for obtaining food, a kitchen and latrines. The rest-houses should satisfy the same conditions as those made for camps and dwellings. The premises must be provided with individual and immovable beds.

Among the operations which native workers most frequently engage in is that of porterage. The measures of protection for workpeople employed in this kind of work have attracted the attention of the authorities and in some colonies, notably the province of Katanga, the maximum of effort required and the loads to be carried are prescribed statutorily. As a matter of fact, any native employed in porterage may not be asked to cover in a day a distance exceeding 25 km., in exceptional cases 30 km. The weight of the load must not exceed: (a) 25 kg. if the load is carried by one man, (b) 45 kg. if carried by two, (c) 60 kg. if by three, and (d) 75 kg. if the porters number four. For each increase of 15 kg. another porter must be employed, and the weight includes, in each of the cases cited above, the object to be carried and where necessary the food of the porter. Finally, one day of complete rest must be given to the carriers after every six days of porterage.

**Pathology**

Data as to mortality among native workers are very scarce, and those that exist only relate to mine or factory workers (South Africa). The few figures which can be quoted give some idea of the situation in this country. Thus, in the Luderitz Diamond Mines, where the number of workers employed was 6,619 and 8,658 in 1925 and 1926 respectively, the mortality per thousand per year was as follows:

<table>
<thead>
<tr>
<th>Diseases</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>5.11</td>
<td>4.65</td>
<td>4.83</td>
</tr>
<tr>
<td>Other respiratory diseases</td>
<td>0.36</td>
<td>0.30</td>
<td>0.33</td>
</tr>
<tr>
<td>Pulmonary tuberculosis</td>
<td>2.75</td>
<td>2.44</td>
<td>2.81</td>
</tr>
<tr>
<td>Influenza</td>
<td>0.89</td>
<td>0.89</td>
<td>0.89</td>
</tr>
<tr>
<td>Scurvy</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
</tr>
<tr>
<td>Rheumatism</td>
<td>0.30</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Gastro-intestinal affections</td>
<td>0.39</td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td>Cerebro-spinal meningitis</td>
<td>0.39</td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td>Intestinal fever</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Other diseases</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Accidents</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7.57</td>
<td>7.57</td>
<td>7.57</td>
</tr>
</tbody>
</table>

In the copper mines of Toumeh, where the personnel numbered 2,397 in 1925 and 2,554 in 1926, the mortality per thousand per year was as follows:

<table>
<thead>
<tr>
<th>Diseases</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>2.93</td>
<td>2.93</td>
<td>2.93</td>
</tr>
<tr>
<td>Pulmonary tuberculosis</td>
<td>3.01</td>
<td>3.01</td>
<td>3.01</td>
</tr>
<tr>
<td>Intestinal fever</td>
<td>0.49</td>
<td>0.49</td>
<td>—</td>
</tr>
<tr>
<td>Dysentery</td>
<td>0.19</td>
<td>0.19</td>
<td>—</td>
</tr>
<tr>
<td>Scurvy</td>
<td>0.19</td>
<td>0.19</td>
<td>—</td>
</tr>
<tr>
<td>Influenza</td>
<td>20.96</td>
<td>20.96</td>
<td>20.96</td>
</tr>
<tr>
<td>Cerebro-spinal meningitis</td>
<td>1.96</td>
<td>1.96</td>
<td>1.96</td>
</tr>
<tr>
<td>Other maladies</td>
<td>4.99</td>
<td>4.99</td>
<td>4.99</td>
</tr>
<tr>
<td>Accidents</td>
<td>5.38</td>
<td>5.38</td>
<td>5.38</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>41.01</td>
<td>41.01</td>
<td>41.01</td>
</tr>
</tbody>
</table>

In the vanadium mines at Grootfontein, where a total personnel of 947 workers was employed in 1926, the mortality was 40.12 per thousand per year, while much lower figures were registered for the tin mines of Karibib and Omaruru, where the mortality was only 6.76 per thousand per year for an average number of 297 workmen in 1926.
The workmen of the Rand Mines number about 80,000. Native workers, however, usually stay less than a year, and this necessitates the engagement of an average of 110,000 workers during the course of the year. The mortality among the natives, about 40 per thousand per year before 1912, was due primarily to pneumonia, which accounted for nearly a third of the deaths. In 1912, the recruitment of natives particularly liable to pneumonia was suppressed, and an enquiry was undertaken into the methods possible for reducing the high mortality from this disease. Prophylactic vaccination (Almroth Wright) and the improvement of general conditions of sanitation and particularly of dwellings was recommended (General W. C. Gorgas). The adoption of these measures led to a reduction in the pneumonia mortality of at least 10 per thousand.

The campaign against scurvy has been carried on with success by modifying the diet as to quality and quantity and recognising the importance of antiscorbutic foodstuffs (see article "Gold Mines").

Incidence of simple silicosis, tuberculosis with silicosis and simple tuberculosis amongst natives on the Witwatersrand

<table>
<thead>
<tr>
<th></th>
<th>1924-1925</th>
<th>1925-1926</th>
<th>1926-1927</th>
<th>1927-1928</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Cases of simple silicosis diagnosed</td>
<td>179,881</td>
<td>177,368</td>
<td>184,937</td>
<td>193,976</td>
</tr>
<tr>
<td>Incidence rate (per cent.)</td>
<td>0.047</td>
<td>0.113</td>
<td>0.199</td>
<td>0.108</td>
</tr>
<tr>
<td>B: Cases of tuberculosis with silicosis diagnosed</td>
<td>335</td>
<td>334</td>
<td>349</td>
<td>347</td>
</tr>
<tr>
<td>Incidence rate (per cent.)</td>
<td>0.200</td>
<td>0.245</td>
<td>0.300</td>
<td>0.245</td>
</tr>
<tr>
<td>C: Cases of simple tuberculosis diagnosed</td>
<td>456</td>
<td>566</td>
<td>787</td>
<td>746</td>
</tr>
<tr>
<td>Incidence rate (per cent.)</td>
<td>0.253</td>
<td>0.316</td>
<td>0.425</td>
<td>0.385</td>
</tr>
</tbody>
</table>
lowing figures (per thousand) for the
period 1924-1926:

<table>
<thead>
<tr>
<th>Disease</th>
<th>Coal miners</th>
<th>Gold miners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miners' phthisis</td>
<td>0.63</td>
<td>0.57</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>3.22</td>
<td>2.46</td>
</tr>
<tr>
<td>Pulmonary tuberculosis</td>
<td>1.70</td>
<td>1.07</td>
</tr>
<tr>
<td>Other respiratory maladies</td>
<td>0.66</td>
<td>0.18</td>
</tr>
<tr>
<td>Influenza</td>
<td>1.90</td>
<td>0.37</td>
</tr>
<tr>
<td>Heart diseases</td>
<td>0.32</td>
<td>0.43</td>
</tr>
<tr>
<td>Liver disease</td>
<td>0.57</td>
<td>0.36</td>
</tr>
<tr>
<td>Dysentery</td>
<td>0.22</td>
<td>0.25</td>
</tr>
<tr>
<td>Meningitis</td>
<td>1.19</td>
<td>0.83</td>
</tr>
</tbody>
</table>

For further details, see the Report of the International Silicosis Conference held in Johannesburg in 1930, published by the International Labour Office.

In the Belgian Congo, more than 50 per cent. of the deaths are due to pneumonia and pneumococce affections, which shows the connection that exists between the nature of the work and these affections (Trolli): special conditions of work, notably heat and humidity, and, as a predisposing factor, fatigue due to what is called the "inaptitude" of the native which makes him expend more energy than would a white man. This makes it essential, in order to diminish the mortality and the morbidity, especially among the natives of the Congo, not only to supply them with every hygienic precaution (adequate clothing, food, lodging, means of adaptation to the climate and new conditions of life), but also to establish the limit between fatigue and over-exhaustion and to determine the amount of energy which the black race can put into each required piece of work (Trolli).

Illness from intestinal parasites has attracted the special attention of colonial doctors. Among the coffee plantation porters in Central America, the following percentage frequency has been noted (Zschucke):

<table>
<thead>
<tr>
<th>Disease</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number examined</td>
<td>196</td>
<td>214</td>
</tr>
<tr>
<td>Ankylostomiasis</td>
<td>43</td>
<td>41</td>
</tr>
<tr>
<td>Ascaridiosis</td>
<td>54</td>
<td>63</td>
</tr>
<tr>
<td>Trichocephalosis</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>Uninjured</td>
<td>20</td>
<td>21</td>
</tr>
</tbody>
</table>

As regards the plantation workers, the causes of death among the workers on coffee plantations in Central America are shown to be as follows, according to the entries in the civil registers between 1907 and 1924 (Zschucke): (for eleven plantations) absolute number of deaths: 2,796; deaths from helminthiasis, 22 per cent.; diseases of the digestive organs, 22.5 per cent.; diseases of the respiratory organs, 13 per cent.; acute infectious diseases, 30 per cent.; rare diseases, 3.5 per cent.; old age, 3 per cent.; undiagnosed, 6 per cent.

Amongst workers on coffee, cocoa, and rubber plantations, especially in Brazil, there occurs an excessive mortality from snake bites.

Ankylostomiasis is particularly frequent among natives, as the development of the larvae is favoured by a temperature corresponding to that of the tropics. In certain tropical regions, 50, 75 and even 90 per cent. of the total population are carriers. Among plantation workers and especially in places where health conditions and sanitary arrangements are defective, the number of the infected is reckoned at 100 per cent. (H. Bruns).

Among the infectious and epidemic diseases, those which most frequently invalidate the native workers are influenza, measles, chicken-pox, mumps, whooping-cough, dysentery, typhoid, typhus, malaria, syphilis and sleeping sickness. Finally, heat stroke and "tropical ulcers" constitute causes of incapacity which must be taken into account.

Particular mention ought to be made of cutaneous infections among wood-workers and those who handle tropical plants and their products (lacs): cutaneous irritations among wood-choppers from the resin of *Rhus vernicifera*; formation of papules and vesicles due to the wood of *Rungus* (Hornsey); nettle-rash among workers handling iroquois wood, etc.; a certain number of cases of occupational dermatitis are caused by parasites (*Pediculoides ventricosus*, *Tyroglyphus longior*, etc.) which grow on grasses and vegetation, etc., which dock labourers, for example, have to load and unload.

Finally, the work of cleaning hemp, practised especially in regions that are particularly dry, exposes the workers to infections often complicated by severe ulcers of the legs as a result of work in irritant stagnant water.

**Prophylaxis**

The most generally adopted measure for protection of the native workers, apart from prophylaxis in regard to tropical diseases, consists in rigorous medical examination on admission.
Every worker in tropical regions ought to have a certificate of fitness before commencing work, which should be attested by a duly qualified doctor. The initial medical examination is now compulsory, for instance, in the province of Katanga in the Belgian Congo, where the causes of disability have been thus classified:

(a) General inaptitude for work (absolute unsuitability): tuberculosis, leprosy, severe and incurable elephantiasis, malignant growths, large goitre, Basedow's disease, trypanosomiasis, trachoma, blindness, severe diseases of the internal organs and bones, extensive ulceration of the soft tissues.

(b) Physical inaptitude for general work, compatible with the performance of light work: old age, insufficient development (Pignet's index above 24), weight less than 50 kg., chest measurement below 78 cm., elephantiasis, oedema, pronounced varicose veins, running ulcers and scars on the legs with permanent adhesions, functional and definite paralysis of a limb, atrophy of a limb, loss of the thumb and index finger of one hand, deformity of certain limbs, flat-foot, hunchback and pelvic deformity, deafness and dumbness, loss of an eye, slight inguinal, scrotal and umbilical hernia.

At the physical examination, attention must be paid to the particular constitution of the different native races. Large chest measurement does not always signify robust constitution; the figure can be small and yet possess great powers of endurance and capacity for work (Bantu race of tropical Africa). Before commencing work the recruit should be brought together in camps described as "detention" camps, for several reasons (Pearson and Mouchet): necessity of a period of rest for workers coming from a distance; possibility of acquiring immunity under most favourable conditions without the effort that the work entails; possibility of administering special diet so essential in the case of natives arriving from regions where the food supplies are subnormal; possibility of deñsensitisation of the new arrivals in order to avoid infection of the camp; necessity of quarantine to detect any contagious diseases contracted in travelling; possibility of effecting necessary vaccination before beginning work.

Apart from the initial medical examination, the usefulness of a periodic examination has been recognised. The Committee of Experts on Native Labour (at Geneva, July 1927) has suggested, particularly for so-called forced labour, the following measures: "Medical examination of every forced labourer ought to be made at fixed intervals during the period of employment, in order to determine whether the worker has remained as fit for the required work as he was at the moment of his engagement, as shown by the medical certificate."

These medical visits necessarily raise the question of the creation of a health organisation to protect the health of native labourers. The Expert Commission mentioned above had recognised the necessity of having sufficient personnel to undertake medical examination and give the necessary treatment. Health measures in places where natives are collected together are all the more essential since the attitude of the native in regard to the doctors is far from satisfactory (reports of the Permanent Committee of the Belgian Colonial Congress, 1921, the Commission for the Protection of Natives, 1922, and the Committee for the Study of Labour Problems in the Belgian Congo in 1925). The application of these measures seems to have been effective, since health conditions are certainly better in States possessing protective legislation in regard to labour.

The medical men sent to the colonies ought naturally to know the conditions under which natives who are recruited in regions far removed from the concentration camps live. Enquiries undertaken in these regions ought to hear especially upon the dwellings and villages, diet, nature of the country, climatic conditions, kind of life and occupations, history of all previous recruitments and history of the race, possibility of women accompanying the recruits (Pearson and Mouchet).

Particular attention ought to be paid to the application of sanitary measures, the simple prescription of sound rules of health being insufficient in countries where education of the individual has yet to be done. As was said in the Annual Medical Report for the Tanganyika Territory for 1925, in the best-equipped camps difficulties are always greatest with natives who cannot be compelled to make proper use of the existing sanitary installations.

Sanitary supervision is especially needed in places of work where workers are engaged who have been abruptly removed from their habitual surroundings, sometimes being placed under new climatic conditions, subjected to a different kind of diet from that to
which they have been accustomed, obliged to execute from day to day regular and often arduous work for which they have not been trained and placed — indeed, morally and physically in a situation where their physiological equilibrium is constantly broken and their organic resistance to disease diminished, at any rate for a time."

Good sanitary conditions cannot, however, be maintained where workers are herded together if the authorities do not possess power to punish infringement of the most elementary sanitary rules. Besides, in such cases something more than simple persuasion is required. It has been said that much could be done by dividing up the concentrations, each having its own proper latrines and incinerators, and placing a responsible head in charge of each of these sections. Regular inspections should be carried out by a European. The institution of incentives, such as extra rations or food to those who have practised the greatest cleanliness, might do something to improve the sanitary condition of camps. Experience so far acquired on these lines would appear to be most encouraging, showing that improvements not to be obtained by compulsion may result from a spirit of emulation amongst individuals.

The organisation of a medical service and of a hospital installation for workers in plantations and working centres in the colonies meets with great obstacles: the expense of engaging a qualified medical man; difficulty in finding a health staff equipped to cope with the multiple demands of the situation. The needs of the colonies and the difficult conditions of the life would not appear to be adequately met with by the engagement of an exclusively European medical service. Thus, for instance, even in 1923, in the French Congo, there were only twenty medical men for 2,450,000 inhabitants (K. Mense). Although efforts have been made to fill the gaps by native health officials, their number is still far from sufficient.

According to information furnished by W. Kouwenaar, Director of the Pathological Laboratory of Medan, the sanitary and medical services are becoming more and more perfect in the agricultural estates on the East coast of Sumatra, thanks to the methods instituted in 1871 by Drs. Schuffner and Kuenen, who were able to reduce the general mortality among coolies from 60 to 11 per cent. during the first eight years of their work at Deli. To day, the centralised hospital service allows of rapid and precise diagnosis and adequate treatment, which were not possible when the medical service was decentralised for each undertaking.

Treatment of slight cases represents a very high percentage (70-80 per cent.) of the medical activities. The normal number of sick undergoing treatment can be placed at about 2 per cent. of the workers, although this figure varies greatly and often reaches a higher rate (25 per cent.) for the members of the workers' family who have the right to treatment.

It has been estimated that a doctor can look after 6,000-8,000 coolies with their families, and that a hospital is needed for 4,000-8,000 workers. In the old plantations, where conditions are good, these figures can easily be exceeded.

The medical service of the Deli agricultural estates actually numbers forty-six physicians, two assistant physicians attached to the laboratory, and a physician-in-chief at the Batak Hospital. There are forty hospitals, with a total of 14,250 beds serving a working population of 300,000 employed persons and an equal number of their dependants.

A very important work is that of hygienic propaganda among the working population. A general inspection of the whole of the personnel (men, women and children) of the plantations is made once or twice a year, with the object of finding out by means of a rapid examination the presence of external visible maladies (such as skin troubles, itch, ulceration, venereal diseases, diseases of the eyes, etc.), making a determination of the haemoglobin (by Tallquist's method), and administering a dose of chenopode oil against ankyllostomiasis.

In marshy regions the size of the spleen is determined and the type of malarial parasite. From time to time, the whole of the population is vaccinated against smallpox; typhoid and paratyphoid.

Every worker who has reported sick is obliged to enter a hospital to undergo treatment or else becomes an outpatient. Every person found to be suffering from ankyllostomiasis is naturally subjected to appropriate treatment.

The medical service has favoured the distribution of tea during work in the fields, in order to prevent the workers from drinking from the small
streams, which are often contaminated. A campaign is waged against flies and for the installation and proper maintenance of latrines, etc.

The danger of beri-beri has been almost overcome, but in cases of the disease, which usually only occurs among recruits, foods prepared from a specially calculated composition are distributed.

Particular care is taken of the children, infants and mothers, etc. Naturally, the medical service carries out a very close inspection as regards affections and infectious diseases.

The expense of such a service can be reckoned at about 12-15 florins per worker per annum. The hospital expenditure, including the payments to the medical service and sinking fund costs, is from 80 cents to 1.20 florins per day.

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**Nickel**

**TECHNICAL DATA**

Nickel (symbol Ni) resembles silver in appearance; its specific gravity is 8.8 and its melting point 1,435° C. It is hardly attacked at all by the air or by weak acids; it lends itself easily to rolling and can be drawn into extremely fine wire.

It is found in its natural state in meteoric iron and also combined with sulphur (pyrothine) and with arsenic (nickeline); but it is mostly obtained from garnierite, which is a hydro-silicate of nickel and magnesium. Almost all the nickel-containing minerals contain cobalt (see that article).

The preparation of nickel differs according to the nature of the mineral; thus, for example, in New Caledonia garnierite which is very rich in iron oxide is treated with gypsum in a melting bath in order to transform the oxidised mineral into a double sulphide of nickel and iron. The matte when freed from iron in a converter liberates pure nickel sulphide which is roasted and converted into oxide of nickel. This is reduced without melting in the form of little pellets or small cubes by contact with wood charcoal in gas furnaces.

A method recently employed comprises melting of the mineral with a view to preparing ferro-nickel followed by electrolysis of the pure nickel.

The Canadian mineral after melting and freeing from iron is subjected to a treatment with the object of separating the two sulphides of nickel and copper. To effect this sodium bisulphate is introduced and converted into sodium sulphate with dissolution of copper sulphate. The nickel sulphate is separated out by liquidation, while the copper sulphate collects in the upper part of the ingots. Refining is done electrolytically.

The production of nickel by the nickel carbonyl (Mond) process consists of the following different operations: sorting of the mineral by means of magnetic separators; concentration; foundry work, where the fritted mass mixed with calcined coke, etc., is heated in a blast furnace. The matte of the nickel and copper sulphides is deposited at the bottom of large basins and there separates from the slag. After passing to the Bessemer converters (to eliminate the iron); the matte of nickel and copper sulphide is broken up, ground and sent to the refinery. Calcination converts the sulphides into corresponding oxides. After intimate
contact with dilute sulphuric acid, copper is extracted. The filtered solution passes to driers and the powder is subjected to reduction in steel towers. The mixture obtained goes to volatilisers where a current of carbon monoxide combines with the nickel and yields nickel carbonyl.

This is decomposed with liberation of carbon monoxide which re-enters the cycle, and nickel is deposited on small pellets which fill the towers. The nickel so obtained is 99.5 to 100 per cent. pure and free from cobalt.

Nickel is used in alloys with iron, chromium and tungsten. The non-ferrous nickel (nickel-copper-zinc) is used in iron and steel works and in metallurgy. Its salts (sulphates, oxides, nitrates, etc.) are used for hydrogenation of oils, for nickel plating purposes, manufacture of accumulators, in chemistry, etc.

In nickel plating the objects are freed from grease electrolytically in a bath of boiling soda, followed by rinsing in water and electrolytic cleaning in a sulphuric acid solution. A further rinsing is carried out and sometimes also a slight fresh treatment with dilute hydrochloric acid.

The nickeling bath contains nickel chloride and boric acid in addition to nickel sulphate.

Mordanting of the pieces can be carried out also with nitric acid or with benzine and lime.

**Sources of Danger**

The sources of danger in the Mond process arise from the carbon monoxide (especially from nickel carbonyl) (see that article). The first enquiries as to the toxicity of this product were made for Mond by Mackendrick (1883), and, following on a serious accident in the factory (1893) causing the illness of twelve workpeople (with two deaths), researches were undertaken at the request of Mond himself by A. Mosso and Armit on the toxic properties of this compound. Since then no accidents have occurred, thanks to the rigorous application of precautionary methods (operations in closed apparatus, totally automatic processes, etc.).

In the other methods the risk of poisoning depends on the different gases and vapours given off (sulphides, oxides, etc.).

The source of injury in nickeling comes from the salts, of which the irritating and caustic action is favoured by the alkaline or acid baths, lime, benzene, etc., which are utilised in the operation of removing the grease from the objects to be nickeled.

**Poisonous Action**

The poisonous nature of nickel and its salts has for long been the subject of discussion. Generally speaking, it is admitted that the oxides and certain of the salts are not poisonous. In the form of pure nickel or of nickel iron it is used for making domestic utensils such as pans, jugs, etc., which in use have not been shown to cause injury to health. Careful experiments by Birnbaum, Geerkens, etc., have shown that considerable amounts of nickel given for a long time with food have not brought about any obvious pathological changes. Other research workers however have brought about in dogs by means of very strong doses (1 to 3 grm. per kg.) intestinal derangement with vomiting, convulsions, collapse and asphyxia; but there is general agreement that fatal poisoning by nickel cannot occur.

The most important of the nickel salts is the sulphate (NiSO₄), which is used especially in galvanic nickeling of copper, brass and iron, etc. It is obtained by dissolving nickel, or nickel waste in sulphuric acid, and then evaporating the filtered solution.

According to the experience of Kohn-Abrest and Agasse-Lafont, every effort should be made to prevent workers handling oxide of nickel from coming in contact with the abundant dust which is liberated. They cite the case of a young woman worker employed for five years in a factory where oxide of nickel was handled ('grey powder'), as well as "black powder" (a mixture of mercuric oxide and iron oxide), intended for the manufacture of accumulators. She was solely engaged in keeping clean the workrooms where oxide of nickel was used. At the end of five years' employment she showed signs of poisoning characteristic of mercury. Neither mercury nor nickel was found in the blood or urine, but both were found in the hair. The authors consider that the presence of nickel in the hair renders probable the influence of nickel in the poisoning in question and that it shows how easily the organism absorbs the substances handled.

In Great Britain cases of poisoning due to nickel chloride and nickel carbonyl are said to have been reported in workers engaged in the extraction of nickel from minerals, but in Germany no similar observation has been made (see article "Nickel Carbonyl").
1925 Chomiakow showed that in a Russian soap factory workpeople engaged on the contact process with a duration of about twenty years' employment on nickel showed no symptoms with the exception of severe headache, which was, however, attributed to vapours of acrolein resulting from insufficient cleaning of the boilers. However, analysis of the air did not show the presence of acrolein and examination of the blood was negative.

In Switzerland three cases of dermatitis were reported from nickel plating in 1922, four in 1924, ten in 1925, seven in 1926 and eighteen in 1927. One case only (1922) was caused by sulphate of nickel.

**PATHOLOGY**

A malady peculiar to persons employed at nickel-plating baths is a dermatitis to which the workpeople have given the name of "nickel itch". According to detailed reports on its occurrence and evolution taken from annual reports of the German factory inspectors, as well as from the observations of Fischer in a large number of factories, the clinical picture varies remarkably. Nickel itch resembles particularly, especially at the beginning, ordinary industrial eczema. Some authorities consider this lesion as the expression of the phenomenon of anaphylaxia (Walthard, 1926).

As a general rule the malady commences by a sensation of burning and itching in the hands, then a pruriginous eruption appears in the web of the fingers and on the wrists and forearms. The finger lesions may extend and involve the nails (Heller). The erythema and the eruption or nodular ulceration may often weep and become pustular, extending at times to the arms and chest, face and all over the body. The cracks in the skin, vesicles and pustules, etc., thus formed set up itching which is increased particularly in the evening and at night. In some isolated cases the affected persons complain of a bitter, metallic taste in the mouth.

Recovery takes place as a rule after a week, although cases are known where the condition has lasted for thirteen weeks.

Sensitiveness to the action of salts of nickel is quite individual. Generally the majority of persons employed at the nickel baths are not affected; nickel itch attacks particularly individuals of weak constitution and women. There is a predisposition to recurrence among those who have once been attacked, so that a change of employment is often required.

Action of the salts of nickel occurs naturally mainly on the hands and arms of the persons employed in the nickel-plating baths who have to dip their hands into the bath in order to hang up the articles or to remove those which are ready, etc. Where contact with the nickel-plating solution is not direct the worker may even be affected when he rests his fore-arm on the edge of the baths or vats or by being wetted from the bursting of bubbles at the surface of the solution, as such bubbles act as a vehicle for particles of the metallic salts. This is the reason why the first signs of the disease always affect the hands and arms. As soon as the workers show the first symptoms they give up their work until the cure is complete. Owing to this, nickel itch rarely assumes a grave character.

According to Helene Kolzowa (1927) the persons who are most exposed to risk are those employed in degreasing, such operations as nickel plating proper being in her opinion less dangerous. On the other hand, Kolzowa has been able to show that women have a more marked predisposition than men. Her enquiry extended over 56 workers engaged on nickel plating, of whom 23 (41 per cent.) showed cutaneous affections; 10 cases were confined to cleaners and degreasers of the articles to be nickel plated, 12 to degreasers and nickel platers and one case affected a nickel plater. In the first group (degreasers) 7 were cases of dermatitis and 3 of eczema; in the second (degreasers and nickel platers), 5 were dermatitis and 7 eczema, and the third (nickel plater) was dermatitis. The cutaneous troubles were more often amongst those newly employed; and after employment for two months the diminution in the cases was obvious.

In studying a large number of cases, Bulmer and E. A. Mackenzie (1925) arrived at the conclusion that the most important factor in causing the eruption is lack of a sufficiently cool atmosphere around the workers. Increase in the temperature of the skin, together with the action of the alkaline sweat, accentuates the irritability of the parts exposed and diminishes their resistance.

A considerable reduction in the number of cases may be obtained by providing adequate ventilation and means for cooling the atmosphere. The eruption once produced may be effectively dealt with, according to these authorities, by the administration of calcium chloride.
Jadassohn and Schaaf (1929), of Zurich, dispute the opinion of Schittenhelm and Stockinger that the handling of nickel is a most frequent cause of eczema and that dermatitis is present in almost all persons employed in nickel plating within eight to twenty days after commencement of the work in question.

According to their enquiries and experimental researches, these authors conclude that the injurious factor is not nickel but perhaps a substance used in the industrial processes (in some cases the cause has been Viennese chalk). Among 700 Swiss nickel platers they only found between 1922 and 1927 39 cases of eczema, of which only one had been with certainty caused by nickel (and this was one of idiosyncrasy). Jadassohn and Schaaf are of the opinion that nickel only causes eczema in persons who have an idiosyncrasy for this substance.

Du Bois (1931) has reported numerous cases of nickel dermatitis amongst workers engaged in nickel-plating using baths at 85° C. The vapour liberated impregnated the working clothes, which, once wet, irritated the skin. Of 570 workers employed in 1928-1929, one-twentieth remained immune. The hot season, abundant perspiration and alcoholic excess constitute predisposing factors as regards this disease, which is very rare when plating is done by the cold process. A first attack, far from conferring immunity, renders subjects more sensitive to later attacks.

**DEMONSTRATION**

Lawrence Fairhall (1926) suggests di-thio-oxalate of potassium as a reagent for the determination of nickel. This method has the advantage of being more sensitive than the other methods proposed, and it allows of a calorimetric determination of very small fractions of a milligram.

**HYGIENE**

Careful persons and those who have already suffered from the effects protect themselves by minute cleanliness, washing the hands and arms with soap and water and especially by the application of grease, glycerine, etc., and treatment of the parts affected by means of an emolient ointment.

Persons who are sensitive or show predisposition should be excluded. Hooks or pincers should be used in order to protect the hands, as well as rubber gloves for use in taking out objects that have fallen into the nickel bath. Careful emptying and cleaning of the vats to remove deposits forming there should be carried out. Good ventilation of the workrooms, removal of steam from the baths and rigorous cleanliness of the workrooms, benches, etc., should be observed.

**LEGISLATION**

Dermatitis set up by nickel is brought under Workmen's Compensation Acts in certain cases (see, for example, the lists of certain chronic maladies of the skin; see also the articles "Nickel Carbonyl" and "Electroplating").

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**Nickel Carbonyl**


**CHEMISTRY**

Nickel carbonyl or tetracarbonyl of nickel, Ni(CO)4, is a compound of nickel and carbon monoxide. Discovered in 1890 by L. Mond and C. Langer, it is a colourless or faintly pale straw-coloured liquid, highly refractive, boiling at 43-44° C., volatile at the ordinary temperature, and solidifying into a crystalline mass of needles at 83° C. The vapour at a temperature of 50° C. has a density of 869, and at 60° C. decomposes with explosion. The vapour burns in the air with a very sooty flame. Nickel carbonyl is soluble in alcohol, benzine, and chloroform; it is not attacked by dilute acids or alkalis, but is decomposed by the action of nitric acid or aqua regia. It gives off a peculiar odour like soot, which is perceptible when the air contains 1 part in 2,500,000. The flame of a Bunsen burner becomes luminous when the air contains 1 part in 400,000. By means of nickel carbonyl pure nickel is isolated industrially from its ores (see article "Nickel").
Nickel carbonyl is formed at the ordinary temperature when carbon monoxide is passed over powdered nickel, but it is made in a quite special manner for the production of pure nickel by the Mond process (see article "Nickel").

**TOXIC ACTION**

Toxic action may be due to accidental emissions of fumes during the manufacture of large quantities of nickel. The channel of absorption is through the respiratory tract. Henriot and Richet (1891) believed that nickel carbonyl absorbed by the blood decomposed slowly and produced carb-oxyhaemoglobin. Langlois (1891) also was of opinion that it combined with haemoglobin; J. Mackendrick and W. Steedgrass (1891) on the contrary concluded, as the result of their experimental researches, that the metal nickel itself was poisonous, which they found not only at the point of subcutaneous injection, but also in the blood, and Wahlen (1902) that nickel carbonyl itself was toxic. Armit (1907 and 1908) could not make out any chemical combination between the haemoglobin and the carbonyl which is absorbed by the serum. If the quantities absorbed, however, are high, the volume of carbon monoxide resulting from their decomposition is sufficient to fix part of the oxyhaemoglobin and induce intoxication. On contact with air, humidity, and carbon dioxide (as is the state in the lungs) the nickel carbonyl decomposes rapidly into carbon monoxide and a compound of nickel. This compound is probably a hydrous basic carbonate slightly soluble in water and two and a half times as soluble in serum, with which it forms a colloidal solution. The toxic property then, does not come from the carbon monoxide, but from this compound. Ogler, however, has not found nickel in the blood. The animals treated by Armit died when their blood contained not more than 0.072 to 0.16 per cent. of carbon monoxide and were not poisoned by iron carbonyl, which contains more carbon monoxide than nickel carbonyl. Rabbits die in 65 minutes after breathing air containing 0.018 per cent. of nickel carbonyl, dogs and cats in 12 to 14 hours.

The peculiar toxicity of nickel carbonyl is due, in Armit's opinion, to the fact that this enters the system as a gas and becomes deposited in the form of a slightly soluble powder in an extremely fine state of division over the immense surface of the lungs. The nickel is dissolved, absorbed by the blood and carried to the organs where it exerts a specific action on the endothelium of the capillary vessels (especially of the brain and suprarenals), setting up haemorrhages.

Its action on the lungs sets up irritation, congestion, and oedema. Elimination takes place through the intestines and kidneys.

Other writers, however, attribute the toxic action of nickel carbonyl to carbon monoxide, which can easily be detected in the blood of the victims, rather than to any specific action of nickel. Whether this be so or not, the toxicity of nickel carbonyl is much greater than that of carbon monoxide.

**Pathology**

In man, inhalation of the gas immediately gives rise to vertigo, sometimes dyspnoea, fever, and vomiting, which soon cease in the open air; 12 to 36 hours later the dyspnoea returns with cyanosis, rise in temperature and cough, accompanied after the second day by bloodstained expectoration. The rise in the pulse rate is not proportional to the rise in the respiration rate; the heart is normal. A fatal issue is ushered in by delirium and other symptoms indicative of involvement of the central nervous system. Death occurs on the
fourth to the twelfth day. On postmortem examination there is found haemorrhage in, and oedema of the lungs; punctiform haemorrhages sometimes extensive, in the white matter and especially in the corpus callosum of the brain (Armit), in the medulla, the cerebral, and upper dorsal portion of the spinal cord; fatty degeneration of the heart, cerebral vesicles, liver, and kidneys (Mott). The same pathological lesions are found in animals poisoned with nickel carbonyl.

HYGIENE

Prevent escape of gas and fumes by carrying on the process in hermetically closed iron chambers. Air containing one-half per cent. of nickel carbonyl is already dangerous. In addition, compressed air should be supplied on each floor of the nickel shed with suitable joints at frequent intervals for fixing a face piece and tube through which to breathe in the case of repairs. The air should be delivered into the face piece at sufficient pressure to keep out any gas.

Instruct the men to test for the gas by holding a flame derived from methanated spirit, which is blue in colour, against it. With a large leak the gas would burn with a yellow flame, but with a small leak a yellow film forms on the surface of the blue flame. This test shows a proportion of 1 part in 400,000 of air. Instruct the workers by notices, etc., as to the necessity of care is advisable.

LEGISLATION

Cases of poisoning by nickel carbonyl are brought under the Workmen's Compensation Act in Great Britain, New South Wales, Minnesota, and New York.

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Dr. Alice Hamilton
(Boston).

Nitric Acid


PROPERTIES

Pure anhydrous nitric acid (HNO₃) is a colourless liquid of which the specific gravity is 1.559. It is not used industrially. Nitric acid is found in commerce in the following forms: (a) crude nitric acid, more or less diluted, has a yellowish colour (due to the impurities it contains) with specific gravity varying according to its concentration (1.33 for 53 per cent.—HNO₃ by weight, 1.49 for 90 per cent.); (b) pure nitric acid, colourless, with variable specific gravity of about 1.40; and (c) red or fuming nitric acid, of which the reddish yellow colour is due to the nitrogen dioxide it contains. It gives off bright red fumes and has a specific gravity of 1.50 to 1.54.

The boiling point of the acid increases at first with concentration, reaches a maximum, and then falls; acid of 25 per cent. strength boils at 194°C. The maximum (123°C.) is reached with a solution of 69.8 per cent.

Nitric acid is a compound only slightly stable under the influence of heat. Even at ordinary temperatures it decomposes under the action of light. This explains why it is generally coloured yellow by the nitrogen dioxide.

It is a very strong acid, acting as a powerful oxidiser especially when heated. It attacks the majority of organic substances and often forms with them nitroderivatives (introduction of the NO₂ group into the molecules). With albuminoid matter it gives a yellow colour (xanthoproteic reaction); and this explains its colour reaction on skin and hair.

Nitric acid oxidises similarly a large number of metals. It converts phosphorus into acid, sulphur into sulphuric acid, and carbon into carbondioxide.

It attacks almost all metals except platinum, gold, and certain metal-forming nitrates. Action is favoured by dilution of the acid (iron only attacked by dilute acid) and is accompanied by a reduction to nitrogen dioxide (N₂O₅). In contact with the air the nitrogen dioxide given off is immediately converted into nitrogen peroxide, which has an extremely irritating and toxic influence (nitrous fumes).

Commercial nitric acid often contains sulphuric acid, hydrochloric acid, iron, and other elements (chlorine, arsenic, iodine, etc.).

MANUFACTURE

Nitric acid is made by:

(a) treating Chile saltpetre with sulphuric acid;

(b) direct synthesis, by combination of the nitrogen and oxygen of the air;

(c) by the oxidation of ammonia.
Nitrous fumes into nitric acid.

Air may be composed of weak nitric acid drips. They then pass into an apparatus for cooling and condensing, of which several types exist.

The Valentiner process, which carries on at the furnaces, the gases arrive at the bottom of the towers, while from above water or weak nitric acid drips. Similarly, air may be injected to convert the nitrous fumes into nitric acid.

Direct Synthetic Process

A mixture of nitrogen and oxygen carried to a temperature of 3,000° C. becomes the seat of a reaction equilibrium $N_2 + O_2 = 2NO$. The nitrogen dioxide content diminishes as the temperature is lowered, but it can be fixed by rapid cooling and is then changed into nitric acid and nitrates (see later).

The operation, improperly designated "distillation", is carried out in cast-iron retorts arranged over a furnace in which very often a current of hot air is made to pass.

The most common mixture used is air. Oxidation is effected by means of an electric arc at high tension — 3,000-7,000 volts — in special furnaces, which usually present the following characteristics:

1. an arc completely filling the chamber of oxidation;
2. rapid and constant renewal of the gases submitted to the discharge; and
3. brisk chilling of the gases immediately after oxidation.

Numerous models of furnaces have been constructed on these principles. The lengthening of the arc is achieved by a magnetic field (Birkeland and Eyde-Moscicki) or by a strong current of air (Schoenher-Guye and Naville-Pauling-Rossi, etc.). The efficiency is increased by 25 per cent. if, instead of air, a mixture of oxygen and nitrogen in equal proportions is used.

On leaving the furnaces, the gases containing 1-2 per cent. of nitric oxide pass into cooling devices constituted of aluminium tubes, around which water circulates. They then pass into a large empty tower. The temperature being then below 100° C., the nitric oxide ($NO_2$) is converted on contact with the air into peroxide ($N_2O_5$). Subsequently apparatus comes into use, with the object of recuperation, which can be done in four ways:

1. The gases are absorbed by water sprays in towers provided with fragments of quartzite. As the operation takes place in the presence of air, all the nitrogen peroxide is
converted, after several intermediate reactions, into nitric acid. A 20-30 per cent. acid only is obtained in this way, and absorption of the last traces of nitric oxide takes a long time.

Concentration of the acid is done sometimes by distillation either at ordinary atmospheric pressure or under a vacuum until an acid of 62 per cent. strength is obtained. To obtain, however, concentrated acid, use is often made of dehydration by sulphuric acid. This is carried out in a large column, where sulphuric acid is introduced above, the nitric acid entering at a lower level. The mixture of the two acids and injection of a current of steam furnish the heat necessary for the distillation of the nitric acid, which is collected in a cooling chamber.

(2) Absorption of the gases commenced by water is finished in towers, through which milk of lime flows. A mixture is then obtained of nitrite and nitrate, which is converted into nitrate by the addition of acid.

(3) The oxides of nitrogen are sometimes absorbed by means of concentrated sulphuric acid. A mixture is then obtained of acid sulphate of nitrosyl and nitric acid, which is used directly in the manufacture of sulphuric acid in the leaden chambers, or when distilled with a sufficient quantity of water yields nitric acid.

(4) The absorption towers are large and costly apparatus. In some factories the nitrogen peroxide has been condensed by cooling before bringing it into contact with water to form nitric acid, but the cooling liquid used has been toluene, cooled by a refrigerating machine. This has given rise to very severe accidents, as it is impossible to prevent escapes at joints of the apparatus, and the mixture of nitrogen peroxide and toluene is a violent explosive ("pancestite"). The tendency, therefore, is to replace the toluene by an incombustible fluid—air.

The Haessuer process does not utilise the electric arc. The nitric oxide is produced by explosion in steel bombs of a mixture of air, oxygen and lighting gas.

Manufacture by Oxidation of Ammonia

Gaseous ammonia obtained by synthesis, or from calcium cyanamide as a starting point, is oxidised by making it pass, mixed with air or oxygen, over a catalyst, heated to 300° C. The duration of contact should not exceed 1/1,500 of a second; and a yield of 85 per cent. is theoretically possible.

The oxidation can be carried out in converters of different models, using the most varied catalysts—platinum, iron-oxide, mixed with other metallic oxides, etc.

This process furnishes a gas with a stronger nitric oxide content than the arc process.

The principal industrial methods of concentration of nitric acid are based either on neutralisation of the acid with soda or ammonia, followed by evaporation and treatment of the dry nitrate with concentrated sulphuric acid, or again by fractional distillation.

This last method is applied in industry with towers for the residual nitric acid coming from the manufacture of trinitrotoluene, of nitro-glycerine, of gun cotton, and for the synthetic acid obtained by the arc process.

Sources of Poisoning

In the course of manufacture these are: escapes from retorts, pipes, and condensers (absolute airtightness in the apparatus is practically achieved, and from this point of view the Valentinier apparatus, which is carried on under a partial vacuum, offers appreciable advantages); inhalation of fumes during emptying of retorts and evacuation of the acid-sulphate in the process, with bi-nitrates; risk of burns and inhalation of nitrous fumes from filling and despatch of carboys due to breakage of receptacles (in warehouses especially); when the acid comes in contact with organic substances (saw-dust, paper, leather, etc.) there is risk of fire, and inhalation of poisonous fumes. Massive poisoning is reported with rapidly fatal issue in the cleaning of receptacles which had contained nitric acid. A fatal case is reported affecting a workman who had been employed for only fifteen minutes in a reservoir which had been washed out several days previously with an alkaline solution made with quicklime (Rambousek).

Lead and mercury poisoning have to be taken into account in connection with the different processes.

In the course of its industrial use: danger here arises chiefly from the nitrous fumes given off in numerous operations during the manipulation of nitric acid of which the following are the most important: preparation of the nitrates of iron (dye industry), of baryta, ammonia, lead, silver, barium,
borne for a short time; and 0.3-0.4 mg.
of for an hour with the usual symptoms
litre of air can be borne without injury
to that
pre-eminently on the respiratory system
reaction).
which they coagulate
considered both in relation to its use in
fact
factories
also
poisoning
similarly given off
when Chile
(silvering,
golden, gilding) ;
industry (refining,
aniline
acid, and
nitro-toluene,
nitro-naphthaline,
picric
acid, and of all the organic bodies
undergoing in their manufacture the
process of "nitration", that is, the
introduction of the NO₂ group),
of indigo black; in the dye industry
(fixing and mordanting); in the metal
industry (refining, pickling, scouring
damascening, gilding); in goldsmiths'
and jewellery trades; in electro-plating
(gilding of copper and brass); in the
printing industry; in etching on zinc,
copper, and steel; in the "carrotting"
of rabbit skins; the manufacture of
felt hats and that of glass pearls
(silvering, etc.).

**Nitrous fumes** may be given off in
the manufacture of superphosphates or
when Chile saltpetre and very acid
superphosphates are mixed. They are
similarly given off in the heating of
manure composed of saltpetre, lignite,
and woollen refuse. The risk of
poisoning by nitrous fumes should
also be borne in mind in fires in
factories or workshops dealing with
nitric acid, celluloid, films, etc.

**Toxic Action**

According to Fischer nitric acid is
the more dangerous on account of the
fact that its toxicity is generally
underestimated. Its action must be
considered both in relation to its use in
solutions and in the form of fumes.

The former exert an oxidising and
nitrifying action on albuminoid matters
which they coagulate (xantho-proteic
reaction). The action of the latter
differs according as pure nitric acid
vapour or nitrous fumes are in
question. Both have a local action on the
skin and mucous membrane, but it is
pre-eminently on the respiratory system
that they provoke symptoms of general
poisoning. The vapour of pure nitric
acid has a slight irritating action similar
to those of other acids: 0.03 mg
per litre of air can be borne without injury
for an hour with the usual symptoms
of irritation; 0.2 mg. can only be
borne for a short time; and 0.3-0.4 mg.
per litre are dangerous doses (see
below).

The great danger of nitric acid
arises from the development of nitrous
fumes, which are no longer respirable
at a strength of 1 per cent. Nitric
acid, as matter of fact, readily,
becomes converted in the course of dif-
f erent industrial reactions into nitric
oxide and peroxide; nitrous fumes are
also evolved spontaneously from fum-
ing nitric acid (see article "Nitrous
Fumes").

**Statistics**

According to Leymann (1906) the amount
of morbidity in nitric acid factories is
fairly high. As a matter of fact, during
the period 1851-1890, 1890-1900, and 1900-1904,
for about 1,044 persons the cases (per cent.)
numbered 33, of which 13% were due to
nervous diseases, 8.7% to respiratory, 11.88 to
circulatory, 12.6% to digestive, 9.39 to
infectious diseases. These values are
generally (except for digestive diseases)
somewhat higher than the average calcu-
lated for 22,547 workers employed in the
chemical industry.

In regard to external lesions, nitric acid
workers show figures considerably higher
than those of the other groups from burns
—11.97 per cent. as against an average of
4.7. Naturally, nitrous fumes play an
important role in respiratory diseases,
while the strong caustic action of nitric
acid is responsible for the occurrence of
burns.

According to the Swiss National Acci-
dent Insurance Fund, reported cases of
poisoning due to nitric acid numbered 4
in 1918, 9 in 1920, 9 in 1921. No case of
burns had been reported or received com-
ensation since 1918.

Generally speaking, the small number of
cases reported as set up by this acid is
accounted for by the reason that cases are
usually included under the statistics for
acids or nitrous fumes.

**Symptoms**

Acute and chronic effects have to be
distinguished. The former include
especially lesions of the skin and
mucous membrane by nitric acid,
more or less profound, according to
the concentration of the liquid and
duration of contact. They appear as
yellow stains and characteristic scars.
Severe cases of necrosis and thrombosis
of the vessels have even been reported.
The severity of these burns can be
judged by remembering that the acid is
strong enough to set fire to clothing
saturated in it.

When inhalation of nitrous fumes has
been slight, no important general
manifestations show themselves beyond
some symptoms of excitation. Persons
suffering from respiratory distress are
particularly sensitive. On the other hand some degree of acclimatisation to small doses of the fumes seems to occur.

In serious cases after inhalation of a large dose those severe symptoms, described in the article "Nitrous Fumes", come on at once.

Chronic intoxication of the respiratory tract by acid fumes is not known, but on the other hand chronic lesions affecting the skin and teeth are met with.

Amongst workmen employed in the manufacture of nitric acid, Weyl has noted a yellow staining of the beard (Xantho-proteic reaction), the hairs of which in time become damaged by it. Eczematous lesions on the hands and forearms have been observed by Combilat among painters using nitric acid. Similarly, lesions are found, or may be found, on the lips and mucous membrane of the mouth, with formation of scars, ulceration and cicatrices, yellow in colour.

The most common lesions are those of the teeth as shown in a necrosis, developing over a period of two or three years and affecting at first the most exposed teeth (incisors). The eroded teeth, of a yellow brown colour and lacking the characteristic brilliancy, become sensitive to changes of temperature, to acids, and the pain is increased when chewing, but gradually ceases as the destructive process advances. Slowly the teeth deteriorate and disappear as far as the crown, this form of destruction being characteristic.

The necrosis begins some weeks after commencement of work—in some cases, only after some years—and is hastened by the habit adopted by certain workers of placing, as a kind of respirator, between the teeth already soiled by acid a piece of stuff on which the acid vapour condenses, and so attacks the teeth directly. The direct action of the air charged with acid vapours given off by the nitration apparatus and nitrated material and inspired through the teeth must also be borne in mind.

The diagnosis of acute intoxication by nitric acid is not generally difficult. On the other hand, serious difficulties do present themselves in many cases where, as commonly happens in industrial processes, nitrous fumes are present. (See article "Nitrous Fumes ".)

**DEMONSTRATION**

Nitric acid stains are quite distinct from those of either hydrochloric or sulphuric acid (orange and yellow tint not disappearing with ammonia).

The determination of free acid can be made volumetrically by means of an alkaline solution of soda or potash. Determination of nitric acid in the visceras is the business of the expert chemist. Different processes have been proposed: that of Schloesing is based on the conversion of the acid into nitric oxide under the influence of protochloride of iron; that of Arnaud and Pade on the insolubility of nitrate of cinchonamine, etc.

Several reactions have also been suggested to bring out the characteristic of nitric acid and the nitrates, but the majority are too sensitive. The expert would know how to select that best adapted to the case in question.

**HYGIENE**

In the course of manufacture all escapes of the gas should be prevented by making the apparatus absolutely air-tight and by frequent testing of the piping; good ventilation and localised exhausts with hoods over the boilers should be provided. Gases that have not been condensed should be carried away by a very tall stack. Liquids should be neutralised by lime or calcium carbonate before they are allowed to enter water courses.

The floors should be of cement and so arranged that in the case of fracture of the receptacles the escaping nitric acid should not present danger. Shaking or upsetting the receptacles should be avoided, and the quantity of acid stored in any one place should be small. Stringent measures should be adopted in the cleaning of retorts, receptacles, reservoirs, piping, fans, as well as in the opening of all vessels containing the product. Similar care is needed in transport by tank wagons. Any room in which the acid has been spilt should be immediately cleared of workers and sawdust should never be used for mopping up the acid, but this would cause evolution of nitrous fumes. Every escape should be immediately stopped up. Workrooms in which gas is present in dangerous amounts should not be entered unless by persons wearing breathing apparatus (oxygen self-contained apparatus or canister respirators containing neutralising material). For first aid see article "First Aid" and "Nitrous Fumes ".

The personnel should be given precise instruction as to the danger, and the best means of preventing it. The wearing of goggles and gloves should be obligatory.

Meticulous care and attention to rinsing out the mouth with alkaline solutions (1 per cent. boracic acid) should be taken to protect the teeth.
Nitric Acid should be reduced to the indispensable minimum. Emptying or pouring should be effected by safety devices. (For details apply to the Inspector.)

In its use: avoid inhalation of the fumes. Ventilating hoods should be provided over the mordanting vats. (For details apply to the Inspector.)

After fracture of carboys avoid especially the acid coming into contact with wood shavings, sawdust, cinders, etc. When acid has been upset it should be collected and washed with water, or sand should be scattered over it which then should be thrown into water to neutralise it. Windows should be opened and the room evacuated as quickly as possible.

Call in a doctor as soon as possible after inhalation of the fumes or as soon as symptoms appear. Those suffering from heart or lung trouble are more susceptible to the toxic action of the acid; they ought to avoid manipulating it. Initial medical examination is desirable.

In Great Britain the chemical regulations (11 July 1922) deal with the manufacture and certain uses of nitric acid. In Norway very stringent regulations have been issued (29 June 1923) for factories manufacturing sulphuric and nitric acids and nitrate of ammonium without making use of electricity in the chemical processes. For electro-chemical factories special measures are enforced in Norway.

In Russia the Order of 10 April 1922 prescribes the individual safety measures in nitric acid factories.

So far as concerns the notification of injury produced by nitric and nitrous acid, this is required in Missouri (United States), and in the U.S.S.R., Switzerland, Great Britain and Finland treat poisoning by nitric fumes as coming within the Workmen's Compensation Act (see also article "Nitrous Fumes").

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Nitro and Amido Derivatives of Benzene and its Homologues


By the term "nitro and amido derivatives" is designated the nitrated or aminoated compounds of the following aromatic hydro-carbides:

1 In the French edition the term "amino derivatives" has been used instead of "amido derivatives" used in legislative texts, since it is a question of the substitution of the group NH for the hydrogen of the aromatic nucleus and not of the substitution of the hydroxyl group of the carboxyl: It is consequently a case of the formation of an amine and not of an amide.
The benzenes, toluenes, xylenes, etc., having undergone nitration once or several times (nitro, dimitro and trinitro benzene and its homologues) and their alkylated and arylated compounds (toluidine, xyldine, cumidine), anisidine, phenetidine and their chlorinated, nitrated, alkylated and arylated compounds (o- or p-anilino, diethylamino-diphenylamine, etc.); phenylendiamine, tolyldiamine; benzidine, toluidine, diaminidine; naphthylamine (α and β), phenylhydrazine and para-phenylhydrazine.

For further details regarding the above, the reader is referred to the articles dealing with the above-mentioned products printed in italic in the preceding paragraph. For the preparation of the nitro derivatives, see the article "Nitrobenzene" and for that of the amido compounds see the article "Aniline".

This article is restricted to information of a general order to be found in various publications under the heading: Nitro and amido derivatives of benzene and its homologues.*

Statistics

Statistics relative to nitro and amido derivatives of benzene and its homologues are to be found in the various articles already referred to. It occurs, however, in practice that a number of cases of poisoning are notified under the general denomination in question here or under the denomination benzene, its homologues and their derivatives*. Thus, for instance, it is found that in Great Britain compensation was awarded in 52 cases in 1920, 29 in 1921-1922, 63 in 1923-1924, 18 in 1925, 17 in 1926, 9 in 1927, etc. Elsewhere it is recorded that 31 cases of chronic poisoning due to aniline were notified in 1925, 33 in 1926, 38 in 1927, 41 in 1928, 26 in 1929 and 24 in 1930.

The 64 cases which occurred between 1925 and 1928 were distributed as follows: 17 due to dinitrobenzene, dinitrotoluene and trinitrotoluene; 14 in the manufacture of aniline; 13 due to paranitraniline; 3 to paratoluidine; 6 to aniline black; 3 to aniline colours and 4 to various products; the remaining 4 cases (2 fatal) were tumours of the bladder reported in the chemical industry.

In Germany (Bavaria) there were reported in 1923-1924 33 cases of poisoning by the derivatives of benzene and its homologues (chiefly amido derivatives); in 1926 18 cases due to the same substances occurred. The cases mostly consisted of skin diseases, bladder trouble and chronic poisoning.

In the State of Ohio, during the period 1921-1927 74 cases were recorded as due to nitro and amido derivatives, 5 of these being fatal; 35 of the cases involved a duration of incapacity exceeding seven days, 24 under seven days, and 10 no incapacity.

In Switzerland, from 1922 to 1927, the various cases caused by these products amounted to 86, 5 involving invalidity and 4 proving fatal. The products in question gave rise to 64 cases of skin disease.

It often happens that serious and even fatal cases cannot be accurately attributed to one definite product, and that they are described in medical journals as cases of poisoning due to a nitro or amido derivative. Thus, for example, the reports of the German factory inspectors contain the statement that 11 cases of poisoning by nitro and amido derivatives were notified in 1920, and 10 cases of dermatitis due to contact with aniline, alizarine, and nitrochlorobenzene colours, etc. In 1921 there were reported 18 cases of poisoning due to nitro-amido derivatives, and numerous cases of dermatitis due to safranine and violetrene. In 1922 38 cases were reported as occurring in two chemical undertakings of the Wiesbaden district. They were, with one exception, which proved fatal, but slight cases. Sixteen cases of aniline poisoning were ascribed to aniline, paranitraniline and paratoluidine, etc.

In 1930 Rosenthal-Deussen reported cases of subacute poisoning due to an aniline homologue in a factory making flypaper. The product in question was an amido compound of the aromatic series used in the preparation of the paste applied to the flypapers and it set up a clinical picture analogous to that caused by aniline and toluidine, as well as characteristic disturbances of the blood; besides cyanosis, irritation of the bladder, haemorrhages, diuresis troubles and derangement of menstruation affecting the women workers in question, there was noted a marked diminution of neutrophil leucocytes and an increase of eosinophils without alteration of the haemoglobin and the red cells.

The nitro derivatives possess properties which are generally similar, and which manifest themselves by a toxic effect on the colouring matter of the blood. In the majority of cases poisoning takes place by way of inhalation and swallowing of times and dusts in which very fine droplets of the various products are present in suspension. Poisoning by way of the skin occurs chiefly favoured by the liposoluble action of certain derivatives, their degree of volatilisation, mechanical friction, perspiration, various skin diseases, etc. Very marked individual variation exists in regard to receptivity for these diverse substances, certain individuals even possessing relative immunity in regard to them. As a general rule, various pathological troubles favour poisoning, which is specially serious amongst anaemic subjects, those with a lymphatic constitution, and those suffering from heart or kidney trouble. Very young, or very elderly, workers are more liable to the risk of poisoning than adults.

As regards amido derivatives, the symptoms of poisoning resemble to some extent those caused by nitro derivatives. It should be noted, however, that the irritant action on the mucous membrane of the bladder which sets up cystitis and
cancer of the bladder is to be attributed to amido and not to nitro derivatives. (See articles "Occupational Diseases: Urogenital System" and "Naphthylamine.") According to R. L. Meyer (1930), poisoning by the amines of the aromatic series is said to be due to a direct reaction between the intermediary products of oxidation and certain elements in the body haemoglobin for instance. However, clinical symptoms like forms of eczema and asthmatic affections are considered by this author as constituting individual idiosyncrasy or as allergies to be distinguished from poisoning properly so called.

As regards cancer of the bladder, Meyer is inclined to attribute it to the pathogenic action of the said intermediary products of oxidation, and he believes the pigment deposited in the neoplastic epithelium to be due to polymerisation of these products.

**HYGIENE**

Hygienic requirements exacted in establishments in which nitro and amido derivatives of the aromatic series are prepared refer on the one hand to the workers and on the other to the workshops.

Workshops must be spacious and well ventilated. Buildings consisting of several floors are not to be recommended since it is difficult to obtain adequate air renewal in these. Construction of platforms is permitted provided that a free space equal to a quarter of the surface of the workshop remains, and that there is between the platform and the wall a space which is either free or covered with a grid having a width of 50 cm. to a metre for the purpose of improving the ventilation. The distance of these platforms from each other, or above the flooring, shall be, wherever possible, 3 metres. A lesser figure may be tolerated in the case of small platforms not likely to interfere with air renewal.

The installation of platforms above boilers for milling and distillation purposes should not be permitted except where absolutely necessary for technical reasons, in which case they must be provided with adequate apparatus and devices calculated to prevent all liberation of gas or fumes from the boiler, etc.

The flooring should be impermeable, have a level surface, and should permit of ready cleansing. It should be conveniently sloped towards a gutter for running off liquid. The material of which the flooring is composed depends on the properties of the products dealt with in the establishment.

Flooring formed of stone flags or tiles with a cement foundation certainly permits of easy cleansing, but it would be necessary to avoid deep grooves between the flags. Concrete, which has not always given good results, should, if used, not be porous and must have a uniform surface. It offers, however, less resistance to attack by acids and hot liquids. Where acids are manipulated, the flooring should be made of earthenware tiles impregnated with tar, the seams between these being filled with asphalt. A flooring of this kind is very acid-resistant, but is not advisable in departments where nitrated and amido compounds which enter into combination with tar and asphalt are manipulated; platforms constructed should be equally impermeable and readily cleansed when used regularly for manipulation of nitro and amido compounds. The walls of the workshop should be so constructed, and the joints in these such, that they can be readily cleansed or limewashed.

Abundant ventilation of the workshops should be provided for, without, however, causing draughts. The roof should be provided with an adequate number of ventilating apertures or windows. Where the workshops are extensive and very high, and especially where platforms are used, they should possess, on one side at least, windows which open.

Buildings in which nitrated compounds of benzenes or trinitrated, etc., compounds of the naphthalene series are manufactured should be constructed of incombustible materials. Processes and working conditions should be so organised that as far as possible the workers are not brought or to direct contact with the nitrated and aminated derivatives.

When these compounds are in a liquid form they should, wherever possible, be transported by means of close piping (pumped, exhausted or compressed). When they are in a solid form, or in powder the best method of transport is by transference from one vessel to another or by withdrawal in closed apparatus or by exhaust. The compressed air used should be led through piping above the roof; where it is likely to prove a source of inconvenience to the workers or to those living in the neighbourhood, it should undergo purification in adequate apparatus. All work involving liberation
of dusts, gases or fumes should be effected in closed apparatus where technically possible.

Distilled products should be collected in receptacles which are constantly kept closed. Substances readily liable to melt should be transported in a liquid state. Solid substances melting at a low temperature should be collected at distillation in closed receptacles connected up with an exhaust device heated by means of a steam jacket or similar device. During work of this nature all contact with the products is to be avoided and likewise all liberation of steam. The operation of withdrawing the cool substances from the receptacles in which they have undergone treatment is always dangerous.

Drying should be effected in hermetically closed apparatus. The back apparatus charged with dusts and gases should be re-utilised in such a way as to form a closed circuit. The drying chambers should be emptied after cooling has been completed. During the operation of emptying, the exhaust apparatus should continue to function.

All efforts must be made to prevent the workrooms becoming soiled with the nitrated and aminated products. Where these products are poured or spilt on the ground they should be removed as quickly as possible. The most practical manner to effect this is to scatter sawdust over them prior to sweeping. The moist sawdust should then be carefully burnt in small quantities at a time. Powdered substances can easily be removed by vacuum.

The workers should be instructed as to the dangers to which they are exposed, and the requisite precautions to be taken as a means of protection, and every effort should be made to convince them of the advantages of abstention from all kinds of alcoholic drink. Necessary articles for individual protection such as clothing, shirts, headgear, shoes, etc., should be provided.

Working clothes should be washed regularly and kept in a good state of repair. Clothing which has become contaminated with nitrated and aminated compounds should be immediately removed in order to prevent the skin coming in contact with these products.

Measures of personal hygiene comprise provision of washbasins, douche baths, etc.; prohibition of all operations in connection with repair or alteration of apparatus, etc., prior to having effected thorough cleansing of the same; prohibition of entry of workers into chambers and recipients without adoption of requisite safety measures, etc.

Workers should not be allowed to keep or to consume food in the workrooms, to change their clothing there, or to leave their town clothes there. Medical supervision: this should include examination on engagement, and periodical examination thereafter. Adequate organisation of first aid includes provision of respiratory masks, oxygen, etc.

Legislation

Women are excluded from factories where nitro and amido derivatives of benzene and its homologues are manufactured, and from those in which these substances are used in France, Germany, Japan (aniline fumes), and in Argentina, etc.

Girls under eighteen years of age are excluded from work of this kind in Great Britain, Greece and the Netherlands, and from twenty-one years of age in Spain and Italy, and from persons under sixteen in Belgium, Greece, Spain, etc. Work in establishments engaged in making or handling nitro and amido derivatives of benzene and its homologues is subject to regulation in Germany, Great Britain, New Jersey and Pennsylvania.

In Germany instructions relating to hygiene as affecting workshops and workers, including medical examination on engagement and periodically thereafter (monthly) as well as prohibition of the work of women and young persons, were issued in 1911 and were published also in Prussia (1911) and other States of the Reich.

In Great Britain the Regulations of 30 December 1908, No. 1310, lay down hygienic measures (working clothes, facilities for personal hygiene) which the employers are obliged to adopt and the workers to utilise as a protection against the risk of poisoning.

Regulations in the two American States referred to above include provisions relative to hygiene in the workshop, to industrial operations, to medical examination on engagement and periodically thereafter, and first aid, etc.

Other States provide for medical examination either on engagement or periodically (Bavaria, Hesse, Italy, etc.). Compulsory notification of cases of poisoning by nitro and amido derivatives of benzene and its homologues is required in France, Germany (Bavaria), Great Britain, the Netherlands, the U.S.S.R., etc.

Compensation is granted in Alberta, Austria, British Columbia, Finland, Germany, Great Britain, Italy (not for amido derivatives); in Massachusetts, Minnesota, New York, Ohio and Porto Rico, Queensland, Switzerland, Venezuela, Western Australia, and in those countries in which occupational diseases coming within a specified definition are compensated.

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Nitrobenzene
(Mirbane Oil)

French: Nitrobenzène (Essence de mir-
bane). — German: Nitrobenzol (Mirban-
öl). — Italian: Nitrobenzolo (Essenza

Nitrobenzene \((\text{C}_6\text{H}_5\text{NO})\), or mirbane oil, is a liquid which is almost colourless or of a slightly yellowish straw colour; it is refractile, and has an agreeable smell of bitter almonds, which is present even in very great dilution.

The specific gravity is 1.099 at 15° C. When solidified by cooling, it melts at 3° C. and boils at 206° C.

It is hardly soluble in water, but mixes in all proportions with alcohol, ether or benzene. It is non-explosive and can only with difficulty be carried away by steam.

Amongst its homologues and derivatives, the most important from the technical point of view are the various nitro-
toluuenes and nitroxylenes, as well as the nitro-chlorobenzenes. Among the nitro-
toluuenes the ortho- and meta- are liquid, the para- is solid. It is very difficult to carry away these products by steam; they are hardly soluble in water, but are readily soluble in alcohol and ether. The five nitroxylenes, some liquid and some solid, present the same capacity for solubility as the nitro-benzenes.

The ortho- and para- chloronitrobenzenes are solid products, which have the same properties regarding solubility as nitro-
benzene.

Nitrobenzene was discovered in 1834 by E. Mitscherlich, and prepared in small quantities from benzene in 1847 by Mans-
field in England, and Collas in France, as a substitute for the natural essence of bitter almonds in the perfumery industry, and sold under the name of "mirbane oil". The manufacture of nitrobenzene on a large scale coincides with the rise of the aniline dye industry (1856), in which it constituted from the start the most important of the intermediate and final products. It is manufactured and used today almost entirely in connection with this industry.

**TECHNICAL FACTS**

Nitrobenzene is prepared by the nitration of benzene by nitric acid. The introduction of the nitrous group (NO₂) in the place of a hydrogen atom into the benzene ring is accompanied by the formation of water, which would cause a gradual dilution of the nitric acid, and, in consequence, a premature arrest of the nitration, before the nitration is exhausted. The sulpho-nitric mixture, composed of concentrated nitric acid and sulphuric acid, were not used, the latter acting as a dehydrator. In consequence, a less concentrated nitric acid can be used with several advantages: larger output, lower cost, and more difficult oxidation, together with less production of nitrous fumes and useless secondary products. The operation is carried out by carefully retaining the apparatus used for the reactions at a lower temperature, and by adding gradually the sulpho-nitric mixture.

The benzene to be used for nitration is obtained by subjecting commercial benzene of a strength of 90 or 50 per cent. to fractional distillation, in order to separate the homologues; the product which passes over between 80.2° C. - 80.8° C. is regarded as chemically pure.

The sulpho-nitric mixture, which only attacks cast iron and iron slightly, is sent to the nitrating room in order to be poured into earthenware receptacles, either automatically by means of compressed air or by hand in earthenware jugs or cast iron acid resisting receptacles. The reaction is effected in nitrating apparatus made of iron or cast iron, equipped with stirrers, refrigerating coils and thermometers.

The acid mixture, which flows from a receptacle above, is allowed to fall slowly into the apparatus containing the necessary quantity of purified benzene. The mixture, kept continually stirred, is maintained first at 25° C. by a circulation of cold water on the exterior of the apparatus. During the last stage, in order to increase the reaction, the mixture is heated to about 50° C. In the mixture there is always an excess of benzene to prevent the formation of dinitrobenzene. If the reaction is properly conducted there is no evolution of nitrous gas. Nevertheless, the nitrating apparatus and the receptacles for acid are provided with exhaust shafts for any poisonous gases which may be set free, if the apparatus functions badly.

Although, as a rule, the nitrobenzene which is formed does not contain dinitrobenzene, it may, on the other hand, contain a little unchanged benzene.

When the heating is finished, the stirring is still kept up for about two hours. The liquid is then pumped into tanks arranged above. On settling, the acid mixture falls to the bottom, and the nitrobenzene floats to the top. The acid is decanted by taps and is driven by compressed air to the sulphuric acid room for regeneration.

As a matter of fact, apart from nitric compounds, this acid contains oxide of nitrogen and the remains of the nitric
ac. Freed from nitrous acid, it may be used for a new nitration, after concentration and the addition of sulphuric acid, or of manure for the dis-aggregation of phosphates.

The crude nitrobenzene is forced, under pressure, into a vat where it is washed and stirred, and then freed from traces of acid by means of a lye or a solution of carbonate of soda.

On standing, the nitrobenzene is deposited at the bottom; it is decanted and separated, by distillation in a current of steam, from unchanged benzene and other hydrocarbons. A second distillation gives nitrobenzene sufficiently pure for technical purposes, and, in particular, for the preparation of aniline. But for the perfumery industry this product must be subjected to distillation in vacuo. Formerly, especially pure essence of mirbane, required for high-class perfumery, was produced by distilling, in a current of steam, the sediment from sulphate of lead containing nitrated compounds, which form in the washing vats and in the residuary acid.

Of late the nitration of benzene has been carried out by a continuous process: the benzene and acid mixture are introduced in equal parts, but without any excess of benzene, such as is necessary in the preceding process, into an apparatus fitted with columns, or into vertical nitrating apparatus, divided up in the form of a labyrinth; it is equipped with a rapidly-moving stirrer, and arrangements for regulating the speed of arrival of the two fluids, and also a cold water circulation. The nitration is carried out by stages as the temperature is raised, and is only in the last columns that it is completed, or — if a sufficiently complete reaction is obtained immediately at the start by means of regulated cooling at an optimum temperature of 50° C. — during the onward passage of the material through the various chambers of the nitrating apparatus.

The resulting emulsion is composed of residuary acid, almost entirely freed of nitric acid, and nitrobenzene, practically free from benzene. A separator, placed at the extremity of the columns, separates the two bodies in a rapid and complete manner, so that the nitrobenzene and residuary acid flow off continually and simultaneously.

The further purification of nitrobenzene is carried out as described above. This automatic process also has the advantage of requiring completely closed apparatus, which must be of a relatively small size in comparison with the output, and also of reducing considerably the danger of explosion. These processes, however, have not been much used up to the present.

The process of nitrating vapours of benzene by means of oxides of nitrogen at 300° to 350° C., and of benzene by means of nitrate of soda and sulphuric acid at a strength of 90-96 per cent. at a temperature raised to 100° C., seem to be now completely given up.

The mono-nitro-derivatives of the homologues of benzene — nitrotoluenes and nitroxylenes — are obtained in a similar way, by nitration of toluene or of xylene in similar apparatus, but at lower temperatures, at 20° C. for toluene, and at 17° C. for xylene. For the rest, the proportions of the acids in the sulpho-nitric mixture are somewhat different (see also article "Di-nitrobenzene").

For use in the dye industry — but not in the case of further nitration in the explosives industry — the isomeres which are formed during nitration must also be separated, especially those of the nitrotoluenes, so that the separation may not take place with the formation of toluidines by reduction of the mixture.

Ortho- and para-nitrotoluenes are present in crude nitrotoluene up to 35 to 63 per cent.; but meta- is only found in the proportion of 2 per cent. The two former are distilled in a current of steam or in vacuo. The orthoisomere passes in the largest quantity. The residue of the distillation is cooled; it contains chiefly para-, which crystallises in lamellar prisms of the rhombic system. After being centrifuged rapidly the residuary mother-liquor contains chiefly ortho-. This residue mixed with the ortho-distilled at the beginning is rectified afresh in order to obtain the ortho- in a purer state.

Speaking generally, the five isomeres of nitroxylenes are not separated, but more frequently the xyldines, which are more important from the technical point of view, are isolated.

Uses.

Nitrobenzene, its homologues and derivatives are almost exclusively used in the chemical industry for aniline dyes and explosives; also, on account of its odour, nitrobenzene is used in small quantities, and in addition on a large scale, as a perfumery product in the manufacture of cheap soaps and other toilet articles, of boot polishes and of polishing materials. It is even used as a substitute for the natural
essence of bitter almond in confectionery and liqueurs. The designation of these products under such names as "mirbane oil" or "essence of bitter almond" results in persons who are ignorant of their poisonous properties using them without taking necessary precautions. Spinner has collected 160 cases of poisoning, of which 31 were fatal, in a period of thirty-five years, occurring equally in industry and in private life.

Nitrobenzene, its homologues and derivatives are subjected to a fresh nitration when they are required for the manufacture of highly nitrated explosives, and, in particular, of dinitrobenzene (see that article).

In the aniline dye industry they are used as they are, or more often after having been transformed into various derivatives. Nitrobenzene and paranitrotoluene are used directly and on a large scale for preparing dyes derived from triphenylmethane, especially fuchsin, by the nitrobenzene process, in which they act, at the same time, as raw material and oxidising agent (see article "Aniline"). In the preparation of dyes derived from anthracene, such as indanthrene, nitrobenzene is much used as a solvent, after which it is recovered by distillation. But the greatest parts of the nitrobenzene and its homologues are used as basic products in the preparation of the corresponding aromatic bases, which are obtained by reduction, for the manufacture of aniline, of benzidine and such homologues as toluidine, xylidine, anisidine, toldidine and dianisidine (see article "Aniline").

Similarly in the dye industry, nitration is carried further in order to prepare, by reduction, starting from the dinitro-derivatives, the corresponding diamines: meta-phenylenediamine and meta-xylxylenediamine, which are used chiefly in the manufacture of nitric colours and colours derived from sulphur.

Nitrobenzene is also used as a basic product in the preparation of meta-chloronitrobenzene, of meta-nitrobenzene sulphoneic acid and of metanilic acid. Nitrotoluene is used also to prepare para-nitrotoluene sulphoneic acid, which is an intermediate product in the manufacture of colours derived from stilbene.

Numerous other intermediate products which are regarded as derivatives of nitrobenzene and its homologues are not obtained by starting from these products, but by direct nitration of the corresponding derivatives of benzene and its homologues, such as ortho- or para-chloro-

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**Nitrobenzene, meta-nitrobenzaldehyde, ortho- and para-nitrophenol, para-nitraniline, or chloronitrobenzene sulphonic acid, or indirectly by chemical transformation of other nitrated compounds, for example: the nitrophenols, by making potash lye act on chloronitrobenzenes; meta-nitraniline by the reduction of meta-dinitrobenzene by means of alkaline polysulphides; para-nitraniline by the action of ammonia on para-chloronitrobenzene.**

**Toxic Effect**

The paths of entry for nitrobenzene and its homologues are by the digestive and respiratory apparatus, and, owing to their great capacity for dissolving lipoids, by the skin.

Their toxic effect is exerted chiefly on the blood, in particular on the haemoglobin and on the central and peripheral nervous system. Whereas the injury to the blood is, as a rule, given the first place from both clinical and pathogenic points of view, the nervous symptoms, especially in serious or subacute cases, are much more pronounced and more violent than in cases of poisoning by aniline or other aromatic bases (Curschmann).

The effect on haemoglobin is to change it into methaemoglobin; and this gives rise to pronounced and characteristic cyanosis, that is to say, a bluish-grey coloration of the skin and mucous membranes, with a dark shade of the arterial blood.

The toxic effect on haemoglobin is strictly in proportion to the change undergone by the nitrobenzene in the body. But this reaction has not been obtained in vitro, or only to a very slight degree; hence it cannot be attributed to nitrobenzene itself.

Lethey was the first to put forward the view that nitrobenzene is reduced in the body into aniline, and that the poisoning is really caused by aniline; but this has been contradicted by Filehne and Erich Meyer, the latter of whom was the first to show that most of the nitrobenzene is changed into para-amidophenol and eliminated by the urine, in conjunction with glycuronic and sulphuric acids.

Small quantities of ortho-amidophenol are formed, in addition to para-amidophenol (Brat). The principal product of the change is thus the same as with aniline. However, a small quantity of unchanged nitrobenzene is eliminated partly by respiration and partly by the urine, where it can be detected by its characteristic odour and by chemical analysis. In experimental
poisoning, in addition to para-amido-phenol, there can be detected para-nitrophenol which also readily changes into para-amido-phenol. On the other hand, aniline has not been found, although Lehmann believes he found traces in the urine. It may, then, perhaps be concluded that the change from nitrobenzene into para-amido-phenol is made, in all probability at least in part, by transition through para-nitrophenol, which is able to give rise — like intermediate products of the reduction of the nitrated groups — to intermediate bodies having a considerable power of producing methaemoglobin (nitroso-phenol and chloronitrophenol).

According to the recent researches of Lipschitz on the disintegration of dinitrobenzene (see that article), it is very probable that the change occurs by transition through the intermediate production of β-phenohydroxylamine, which has a great power of producing methaemoglobin.

During this change, first, by a kind of process of poisoning, intermediate products are formed — perhaps, in principle, the same for all the nitro- and amido-derivatives which act upon haemoglobin — which attack the haemoglobin and reduce the oxyhaemoglobin.

Opinions on this point, as well as on the spectroscopy of the blood in nitrobenzene poisoning, are still very divergent. As a matter of fact, Starchow found the band of acid haematim, and Filehne, in his experiments on the dog, has described, as characteristic of nitro-derivatives, an absorption which is not very distinct, situated in the red part of the spectrum, which could only be detected in strong concentrations. This band is not identical with that of haematim and is found sometimes — during life — more to the right, and sometimes, more to the left; it did not disappear on reduction by means of ammonium sulphide, but only changed its position. This band has also been described by other authors (Roehl, Weissenstein); however, the most recent researches have Lipschitz and the certain presence of methaemoglobin spectroscopically, either in animals (Gibbs and Reichert), or in man (Erlich and Lindenthal; E. Meyer). Numerous observations made during occupational poisonings (Brat and others) have confirmed that the formation of methaemoglobin is the most important and decisive phenomenon in the development of the disease.

Besides this action, nitrobenzene has, as have all the toxic nitrated derivatives of the aromatic series, a destructive action on the red blood cells, which is much more marked than that of aniline and of the corresponding aromatic bases. This different intensity in the toxic action can be explained by the greater selective affinity of nitrobenzene for lipoids, and by a slower removal of the poison during metabolism; thus there is a possibility that the aromatic nitro-derivatives destroy the red blood cells first, and only then change the free haemoglobin into methaemoglobin, whilst the change caused by the aromatic bases must take place in the interior of the red cells (Brat, Curschmann). Perhaps, however, it is more likely that the formation of methaemoglobin takes place in both cases, first in the intact red cells; but that, in poisoning by the nitrated derivatives, there is in addition to that, and later, a great destruction of red cells with liberation of methaemoglobin (Engel). Hence, the action on the mass of blood is much more durable, since the haemoglobin, once liberated, is completely lost for regeneration. This injurious action on the red cells is seen in animals as well as in man, taking place more slowly and in a more sluggish manner than that exercised on the haemoglobin. Generally, and only after a few days, a diminution of the number of red blood cells is found, as well as alterations in their shape: poikilocytes, with numerous micro- and macrocytes, schistocytes, phantom cells and the appearance of Heinz's corpuscles. Methaemoglobinuria is also sometimes observed in serious cases. A little later regeneration forms appear: polychromasia, normoblasts and often a pronounced leucocytosis.

The direct action on the nervous system, which is considerably stronger than in anilism, is independent of blood changes and appears clearly in the experiments on animals (Filehne, Haldane, Makgil and Mavrogordato), especially with such animals as rabbits and mice, which offer great resistance to an action on the blood. These experiments seem to contradict the nervous symptoms stated as observed in man, which are attributed chiefly to blood lesions and anoxaemia.

The chief of these symptoms is the paralyzing action of nitrobenzene. It acts upon the sensitivity, motility and excitability of the reflexes, and on the centres of the medulla oblongata, with diminution in blood pressure, and, at first, quickening of the respiration, followed by paralysis.

Irritating action on the central nervous system is much less pro-
nounced, at least in the first stage of poisoning, than in the case of aniline. In animals, motor stimulation, cramps with opisthotonos, and direct muscle stimulation with stiffness and contraction of the muscles, are observed before the appearance and at the onset of general paralysis and immediately before death, especially in the case of serious poisonings, following rapid absorption and conditions favourable for strong doses (Filehne). In man this action seems to be less definite; and the cramps which appear in serious cases, during coma, appear to be associated with forms of asphyxia.

The sensorial and sensory parasthesias and hypoesthesias must be attributed to the involvement of the peripheral nerves. In spite of the presence in the urine of the same principal product of elimination, i.e. para- amidophenol, as is also found in anilism, nitrobenzene does not obviously originate the vesical lesions which are produced by anilin. In acute poisoning by nitrobenzene, death is due to paralysis of the respiratory centre.

The toxic and fatal dose for man is very variable and differs according to the method of administration, the conditions of absorption and re-absorption. With animals this dose naturally varies according to the different species: rabbit, 0.6-0.7 grm. per kg., if given by the stomach (Ziegler), and 0.5 per kg. if given by the skin, fatal in 52 hours; cat, 0.4 grm. per kg. if given by the skin, fatal in 9 hours (Dambieff); 0.5 mg. per litre of air is introduced for 6 hours; slight symptoms after 24 hours with recovery, and also after a longer period of exposure to a greater strength (0.6 mg.; K. B. Lehmann and his pupils).

Subcutaneous injections made in fifteen different places, of 0.6 grm. per kg. in the rabbit produce poisoning in one hour; but if the injection is made in one place, no symptoms appear after five hours (Filehne). It can, therefore, be accepted that when re-absorption is rapid and complete, the toxic and fatal dose is considerably smaller than the experiments on animals suggest. It is generally considered that women, especially during the menstrual period, and young persons are more susceptible than adult men to the action of nitrobenzene.

The fact that resistance to the poison is greater in persons of robust health than in persons of poor health and particularly in thin persons, may be due to the formation in the fatty tissues of a harmless deposit of the poison. The part played by this deposit finds a satisfactory explanation only in cases of acute poisoning. Febrile diseases, such as influenza, favour the appearance of acute symptoms of poisoning (Bachfeld). It is also certain that drinking alcohol, even in moderate quantity, increases considerably susceptibility to the toxic action of nitrobenzene and of other nitro- and amido-derivatives of the aromatic series, and may even favour the development of an acute form of poisoning (Mohr) (see also article "Aniline"). This characteristic action of alcohol appears to be due partly to the fact that it "mobilises" the poison suddenly out of the relatively harmless deposits present in the fatty tissues, and partly to the intensification of cellular respiration which accelerates the reduction of the poison into phenylhydroxylamine (Lipschitz), which in turn appears to intensify the poisonous action in the case of febrile diseases.

The toxic action of the homologues of nitrobenzene, up to the present, is not so well understood. It has only been studied experimentally in animals, for it seems that acute occupational poisonings have never yet been observed in man. The action on haemoglobin in particular seems to be lacking, perhaps on account of a different transformation of the products during metabolism. Thus, for example, ortho- nitrotoluene is eliminated in the dog chiefly as uronitrotoluene acid, with the ortho-nitrobenzylic alcohol combined with glycuronic acid, and as quite small quantities of ortho-nitrobenzoic acid. On the other hand, para-nitrotoluene is eliminated chiefly as para-nitrobenzoic acid and para- nitrohippuric acid, the first being combined with glycocoll (Jaffé). The oxidising process attacks first the methyl group, all the more easily as it is in the para position. The nitroso group of para-nitrotoluene is prevented by reason of the reduction of the nitrate group, and especially by the intermediate formation of the hydroxylamine group and by the entrance of a hydroxyl group coming from the nucleus.

The action of nitrotoluences on the nervous system is less definite than that of nitrobenzene. The ortho-isomer seems to be the most toxic, and causes, but only when it is absorbed by the skin, temporary phenomena, first irritation, then paralysis of the central nervous system (Dambieff), and finally death (Ziegler). When introduced by the digestive organs, the three isomers can scarcely be called poisonous, animals being able to sustain for a long time,
without serious disturbance, doses of 2-4 grm. of the ortho-isomere and even 5 grm. of the para. Nitrotoluene, being hardly volatile at all, has not led to poisoning by the respiratory paralysis during experiments on the inhalation of its vapours (Ziegler).

According to these experimental researches, it may be accepted that the nitrotoluenes are only slightly toxic compared with nitrobenzene.

Sources of Danger

The ease with which nitrobenzene and its homologues are absorbed by the skin explains the reason why the skin is the most important portal of entry for the poison in cases of acute occupational poisoning. In industry this occurs owing to the wearing of clothes badly soiled with splashes, and with condensation of vapours contained in the air, or impregnated by the product due to faults of working in the apparatus or accidents, or more commonly due to lack of cleanliness on the part of the workman, who does not change his working clothes sufficiently often. The inhalation of fumes of nitrobenzene given off from clothes is also a factor which must not be overlooked, although it is of much less importance in acute cases than in poisoning by aniline, because the fumes of nitrobenzene have a weak vapour pressure and are not easily conveyed by steam.

The digestive organs are only of importance in case of accident; several times workmen in the chemical industry have been the victims of serious acute poisoning, as they have swallowed in error large quantities of nitrobenzene, attracted by its agreeable odour and ignorant of its toxic properties.

Danger of poisoning from soiling by contact during technical operations is relatively small, because in big factories where it is made, especially in the aniline industry, and where the final product is utilised, completely closed apparatus only is used (even though this is not the case for solid dinitrobenzene), and also a sealed system of pipes for transportation. The manufacture and direct utilisation of the derivatives of nitrobenzene in the dye industry are much less important than aniline (see that article), except in the case of the production of the triphenylmethane dyes. Hence, cases of acute poisoning by nitrobenzene are much more rare than by aniline. But in the case of defects in working of the apparatus, or during cleaning or overhauling, especially during soldering with lead, danger of acute poisoning becomes greater either from soiled skin, or from the inhalation of vapours. On the other hand, the fumes coming from small leaks in the nitrating apparatus and from the distillation, or those given off during the flow of the acid of nitration or of the washing fluids, explain the higher incidence of chronic disorders among nitrobenzene workers than among aniline workers.

Statistics

Figures of cases of nitrobenzene poisoning are difficult to give, as in the reports of inspectors and in the statistics relating to compensation of industrial cases, these cases are generally shown as cases of poisoning by benzene and its nitro- and amido-derivatives (see that article).

Spinner, in 1905, collected 160 cases of poisoning, of which 31 were fatal, reported over a period of thirty-five years; Grandhomme collected 60 cases, with 23 deaths; Adam reported 15 cases, with 3 deaths, from ingestion of the poison; 6 cases, with 2 deaths, from inhalation; 2 with 1 death from skin absorption; and 5 in which suicide or abortion was intended, wherein there was a fatal result in a very high proportion. Of these 28 cases, 9 were of occupational origin.

Pathology

The classification of poisoning under the headings of acute, subacute and chronic is based less on the evolution of the poisoning than on the way it has developed; whether rapid absorption of the poison, followed by immediate symptoms of poisoning, or repeated absorption of quite small quantities, the clinical picture is only established on the aggregate of effects due to functional accumulation.

(1) The acute form. — Clinically, this is characterised, at least, in the early stages, by methaemoglobinæmia; herein there is a resemblance to the clinical picture of acute anilism. The skin is pale, of a bluish-grey colour, especially pronounced on the visible mucous membranes, upon the lips, the nose and the ears. This coloration may be distinguished from natural cyanosis, caused by a deficiency of oxygen, by the shade, tending more to the grey. The blood itself is of a dark, brownish colour, almost black, and shows with the spectroscope the absorption band of methaemoglobin (see above, Toxic Effect).

"Among nervous disorders, those due to the paralysing action of nitro-ben-
It is of a dark colour, due to products of transformation freed by oxidation from para-aminophenol, especially in the first days of intoxication. This colour deepens still more on the surface on exposure to air, just as in poisoning by aniline (see below Detection). The urine does not directly reduce a solution of copper sulphate, but only after preliminary boiling with hydrochloric acid, which separates the glycuronic acid combined with amidophenol and that can be detected by reduction and its lavo-

deratory property. The elimination may last as long as two weeks. Haemoglobin, as methaemoglobin, passed in the urine as such, can, in very severe cases, be detected from the first days, either by the spectroscope, or by chemical reaction, or even by the micro-
scope. Urobilin, urobiligen, and sometimes haematoporphyrin can be detected as a rule for a long time.

(2) Subacute and chronic forms. — These forms follow upon repeated absorption of small doses of the poison. They are much more common than the acute form, and, in the slighter cases, indicate their presence by pallor which is due to a slight anaemia and is usually accompanied by slightly subic-
teric coloration of the sclerotics. This pallor, which is characteristic for the most part of workers manipulating nitrobenzene, makes it possible to distinguish them readily from aniline workers. Anaemia is the leading feature of the clinical picture; as a rule, there is no methaemoglobinaemia, or, if it is present, it disappears rapidly after the cessation of work.

In cases of moderate anaemia, the reduction in the number of red blood cells and in the content of haemoglobin is slight, often much slighter than the pallor of the skin would have led one to suppose; the colorimetric index is normal or diminished, while the blood formula is hardly altered morphologically. In serious cases, examination of the blood shows changes similar to those met with in the acute form: forms of regeneration of the red blood cells are more or less definitely present; there is no marked leucocytosis; enlargement of the spleen exists, but it is not serious. Nervous disorders, with fatigue and headaches, loss of appetite, and, more rarely, feelings of sickness, are common, even in the slightest cases. Complete recovery requires, in serious cases, several weeks; the urine may possibly show, only in the first days, a slight dark shade and contain paramidophenol; but the presence of urobilin may often be detected and last a long time.

As in poisoning by the other aromatic nitro-derivatives, cutaneous affections may occur in the form of a pustulous eruption, nodules or moist eczema, with redness and swelling (Pohl).

It is not possible to describe the clinical picture of occupational poisoning by nitrotoluene, for particulars relating to poisoning in the case of man are wanting.

Detection

(1) In the air. — Pass at a moderate speed large quantities of air — at least 100 litres, or, better still, 1,000 — containing the fumes to be analysed through absorption tubes filled with absorbing substances, such as activated carbon. Extract the nitrobenzene contained in the absorption tubes with ether; repeat the extraction with small quantities of ether, or better still, in an extraction apparatus. Evaporate the ether; reduce the residue to aniline by means of powdered zinc and dilute hydrochloric acid. Set the aniline free from the aqueous solution of chlorohydrate of aniline by the addition of sodium or potassium lye until a feeble alkaline reaction is established. Distil the aniline in a small apparatus sufficiently to obtain 25 c.c. of liquid. When aniline is simultaneously present, the nitrobenzene should be isolated from the extract by longer distillation with steam in an acid solution, and the reduction should be carried out on the distillate: Aniline is easily detected in the distillate by the violet coloration which it gives with a solution of chloride of lime.

Quantitative estimation is done by gravimetry after conversion into tribromaniline by means of bromine water (see article "Aniline").

(2) In the urine. — Saponify the urine by making it boil with a weak solution of hydrochloric acid. Detect the principal product of elimination, i.e. the para-aminophenol, by means of the reaction of indophenol, or of nitration and combination with appropriate groups. These reactions are more sensitive when they are carried out with an ethereal extract of the distillate, obtained after saponification of urines rendered alkaline.

Test for para-nitrophentol. — Take up again the residue of the acid ethereal extract of the urine with weak hydrochloric acid. If the indophenol reaction is negative, reduce with powdered zinc. A positive reaction with para-amidophenol, which is the indophenol reaction, shows para-nitrophentol. This reaction is useful for making a differential diagnosis in poisoning with aniline. It does not, however, succeed in every case. In serious cases the presence of nitrobenzene in the urine is recognised by its characteristic odour. Distil the acid urine in steam, then reduce the distillate with powdered zinc and hydrochloric acid; aniline forms in a positive case.

Hygiene

First of all it is necessary to ensure that workers do not come in direct contact with, or become soiled by, the product, and, further, to avoid the formation and spread of toxic fumes. It is, therefore, necessary to provide against eventualities, and to use only closed apparatus for the manufacture of the product, for its subsequent use and transport. Transport, as well as the emptying of receptacles, should be effected through closed pipes, either by the use of compressed air or by aspiration. The displaced or aspirated air should be directed on its exit, either outside or into chimneys. Avoid the evolution of fumes containing nitrobenzene and nitrous gases by using for distillation or washing only nitrating apparatus furnished with exhaust flues reaching above the roof or connected with an exhaust system.

Nitration should be closely watched, and especially the maintenance of adequate temperatures, and stirring effected during violent reactions, in order to avoid the evolution of vapours and nitrous fumes, as well as the risk of explosion. When the work-
places are constructed, good ventilation and natural aeration should be provided. The workrooms should be high, provided with windows, skylights and other well-arranged openings for ventilation.

The introduction into the rooms of working platforms which reduce the height of the ceiling should be avoided as far as possible; where they exist, they should not impede the free circulation of air, either by too large a surface, or by being pushed up against the walls. In any case they should not be placed above the apparatus for nitrating and distillation. Natural aeration, especially during hot weather, and under certain circumstances, should be completed by an artificial system of ventilation.

The floor should be impermeable, if possible smooth and sloped towards drainage channels; it should not be made of asphalt, or mixtures of tar, because these absorb and accumulate nitrobenzene.

**Personal hygiene.** — Suitable working clothes should be provided, which should be changed often so that they do not become unduly impregnated with the toxic product; gloves are necessary and should be frequently changed and cleaned; instruction should be given to workmen on the toxic properties of the products manipulated, and on the necessity for changing working clothes when they have become much soiled; and also on the special danger which follows the taking of alcoholic drinks.

Douche baths should be installed, and also cloakrooms and dining rooms. Medical examination on commencing work, and suitable periodical examinations thereafter, fulfill the object of removing from work in good time all workmen showing signs of chronic poisoning, such, in particular, as icterus and anaemia.

**Legislation**

The measures relating to the employment of women and young workers in the manufacture of nitrobenzene are the same as those laid down for benzene, its homologues and their nitro- and amido-derivatives (see these articles).

Some detailed instructions on the equipping and working of these factories, as well as on the personal hygiene of workers employed in them, are contained in regulations laid down in Germany and Great Britain (see articles "Nitro- and Amido-Derivatives", "Aniline", etc.).

See also the same articles for information regarding compensation for injuries by nitrobenzene of occupational origin.

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**Nitrocellulose**


**Chemical Composition and Properties**

Cellulose is the name given to the principal constituent of the cell walls of plants. In the manufacture of nitrocellulose, raw cotton for spinning is used or linters (short staple cotton left on the cotton plant after the long staples have been picked) and waste cotton from spinning and weaving. Chemically-prepared wood pulp, treated with bisulphite and bleached with chlorine, may be used instead of cotton.

Of all natural cellulose substances, cotton contains that which possesses the most stable chemical properties. The empirical formula of cellulose is \( (C_6H_{10}O_5)_n \), or according to other authorities \( C_{13}H_{22}O_10 \) or with doubling of the formula \( C_{26}H_44O_20 \). Treated with a mixture of nitric and sulphuric acids, it gives rise to mono-, di- and tri-nitrates according to the concentration of the acids, the duration of their action and the reaction temperature, the nitro group replacing the hydrogen atoms. Several nitratred forms are known, of which only two are extensively used: the combination with maximum nitration (chiefly for guncotton or hexa-nitrocellulose), the formula of which, according to Marshall, is approximately \( C_6H_4(NO_2)_6 \), with 14.14 per cent. of nitrogen soluble in acetone, acetic ether insoluble in alcohol, ether and nitro-glycerine and the less highly nitrated celluloses (pyroxylene) of which the approximate formula is, according to Marshall, \( C_6H_4(NO_2)_7 \), with 11.11 per cent. of nitrogen, soluble in a mixture of alcohol and ether, and used in the manufacture of collodium.
A mixture of mono- and di-nitrate of cellulose dissolved in a mixture of alcohol ether gives collodion, well known as a medicament and in the manufacture of celluloid, etc.

In deciding whether a nitrocellulose is to be regarded as a dangerous explosive, the important factor, apart from the nitrogen content, is the degree of humidity. Experiments have shown that soluble pyroxyline with 12.3 per cent. of nitrogen, with a humidity of 26 per cent., could only be exploded by means of complicated appliances, such as the application of fulminate of mercury with intercalation of an initial charge of picric acid. In practice soluble pyroxylines with less than 12 per cent. of hydrogen and a humidity of 30 per cent. may be regarded as non-explosive. When ignited they burn out quietly with a high flame. Diminution of the degree of humidity increases the danger of explosion, and the greatest caution is therefore required in drying nitrocelluloses.

**Production of Nitrocellulose**

The various kinds of raw material referred to above contain various impurities (fats, gums, etc.) which have to be eliminated before the nitration of the cellulose is proceeded with. The waste products from spinning and weaving are first of all sorted, carded and degreased. The linters require only carding. The other products are submitted to lixiviation (in a solution of caustic soda at 1 or 2 per cent.) in an autoclave (temperature 100-140° C.), which renders the cotton absorbent and removes from it any pectic matter as well as most of the hydrocellulose. This is followed by treatment with hypochlorides and drying. This treatment is specially utilised in the preparation of collodion used in celluloid factories.

Nitrification of disintegrated, purified and dried cotton is effected by immersion from eight to twelve hours in a mixture of concentrated nitric and sulphuric acid. The composition of the baths varies according to the degree of nitration it is desired to obtain and the method followed. The older method is to utilise containers, troughs or pots for the purpose, while the more modern process is effected in a centrifuge. In the first case the cotton, after being weighed, is plunged into troughs filled with the acid mixture and withdrawn after immersion lasting some minutes. It is compressed to remove the excess of acid, and it is then transferred to a stoneware pot (reaction pot) furnished with a cover.

When the nitration reaction has been effected the contents are poured into centrifugal machines which eliminate a certain quantity of the residual acids (acid centrifugalisation).

The toxic fumes given off during the reaction are removed by means of a chimney or led to a condensation chamber.

The soluble pyroxyline, having been centrifuged and discharged, is immediately immersed in large vats of cold water, the water being constantly changed. The acid is partially eliminated by diffusion in the water. The cotton is afterwards centrifuged once again, and finally undergoes washing in hot water.

The dipping process in centrifuges (Selvig process) permits of better hygienic conditions in the nitration rooms, for the successive operations of immersion, compression, reaction and acid centrifugalisation are effected in the same apparatus without necessitating discharge of the material. The apparatus, which is a centrifuge or hydro-extractor, revolves, after receiving the acid mixture, at a slow rate; the charge of cotton is gradually immersed and the cover closed down, and the apparatus is left to revolve for half an hour. Nitration is effected thus, and by increasing the speed the material can be dried by eliminating the excess acid.

After centrifuging, the cotton is discharged and transported to a stoneware bath known as a "hydraulic transporter", consisting of a sort of cupboard into which the cotton is introduced, being immediately immersed and carried away by a strong current of water.

Discharging of nitrocellulose from a Selvig and Lange centrifugal drier is, however, accompanied by risk due to sudden decomposition and ignition of the product.

In the Thompson process, in which the same container is used for these operations, the nitration acids are slowly replaced by water, which is brought about by the difference in density. The operation lasts from two and a quarter to two and a half hours, and the nitrocellulose leaves the apparatus after complete rinsing.

The guncotton is next purified by successive washing in boiling water, sometimes in slightly alkaline water in large wooden vats, as far as possible hermetically closed and with very cautious manipulation, as nitrocellulose containing traces of acid or unstable nitrated products decomposes readily. In this case rinsing in cold water follows.

Rendering the guncotton homogeneous is effected by reducing to pulp in pulping machines similar to those used in
papermaking or by suspension in water and shredding it in a cylinder furnished with blades and revolving at great speed. There follow further operations having for their object elimination of foreign matter from the guncotton (levigation, decantation, drying in centrifugal machines until the humidity of the guncotton is 25-30 per cent.). In this damp state the guncotton, which can be handled without danger, is compressed into small blocks and packed in wooden cases. The product obtained is pure white; if, however, it develops a yellowish tinge (decomposition of residual acids) it is a sign that there is a tendency to explosion. To accelerate stabilisation and bleaching, there is often added to the hot water in the final washings soda, ammonia, permanganate of potash, etc. Well-stabilised guncotton should be able to withstand heating for two hours at 132° C. in an amyl alcohol bath without decomposing or igniting.

Guncotton is very sensitive to frictional electricity. The drying is therefore usually carried out on metal slabs in frames which divert to earth any electricity which may be present. Any exceeding of the dry temperature of about 50 degrees is indicated by a thermometer which starts an electric alarm.

Manipulation of material with less than 20-30 per cent. humidity is to be avoided.

**Uses**

Nitrocellulose is chiefly used in colloidal solution for the preparation of smokeless powder (see article "Explosives"), of artificial silk (see that article), photographic films, cellulose varnishes and lacquers, etc. By treating oils with nitric acid to obtain substitutes (see article "Rubber or India-rubber Industry"), viscous semi-solid products are obtained, which, when mixed with nitro-cellulose, give a product known as "Velvirl" fairly similar to gutta-percha and India-rubber. Nitrocellulose used as raw material can be dissolved in a damp state. Consequently centrifugal drying is not required, the water being driven out by the alcohol (dehydration) (see also articles "Rubber or India-rubber Industry" and "Varnish and Lacquer Manufacture").

**Dangers**

The storing of large quantities of nitric acid always involves grave risk. When in a pure state and kept in a place that is free from damp, the large iron vats containing it are not attacked; but diluted acid dissolves iron and generates hydrogen which, in combination with the oxygen in the atmosphere, may form an explosive mixture, capable of igniting and bursting the iron receptacles. When the acid is contained in glass carboys with straw covers and these are broken, the acid reacts on the straw, as in fact on any organic substance whatsoever, causing ignition and liberation of nitrous fumes. The mixing of acids being dangerous on account of the liberation of nitrous fumes, it should be effected in closed apparatus. The greatest risk, however, occurs when nitrous fumes are liberated during action of nitric acid on organic and metallic substances (see article "Nitrous Fumes"). They also exert a local caustic action on the skin and mucous membrane. Finally, centrifugal driers, which in course of rotation suck in atmospheric moisture, may cause decomposition and explosion of nitrocellulose in the apparatus.

**Toxic Action**

According to Lehmann, the quantity of nitrous fumes sufficient to cause marked irritation of the respiratory passages would be 0.2 mg. per litre of air; 0.5 mg. could only be tolerated for a very short time. The acids used (particularly sulphuric acid) often contain small quantities of arsenic, which may be given off in the form of arseniuretted hydrogen (see that article) and inhaled during reaction on metals. These quantities of arsenic are generally, however, so small that no case of poisoning imputed to this cause has so far been reported. In one case, in which death was ascribed to the inhalation of nitrous fumes, traces of arsenic were discovered in certain organs of the victim (Holtzmann). The beard and whiskers assume a yellowish tinge as a result of the reaction of the acid on the capillary substance. Teeth are likewise discoloured and damaged by nitrous fumes.

Preparation and use of nitrocellulose involves exposure to the risk of fire and explosion, a risk which is present from the commencement to completion of the industrial processes. Danger of explosion occurs particularly during drying, now effected in safety chambers provided with a vacuum or by dehydration by means of alcohol, followed by drying. Handling and transport of dry nitrocellulose also entails grave risk for the workers. In the cleaning and emptying filters containing guncotton debris impregnated with acid. These facts are true of stabilised
nitrocellulose, the risk being very much greater for the less stable varieties, which tend to ignite and explode even without any apparent cause, merely owing to decomposition at an ordinary temperature. It is, therefore, indispensible that only stabilised qualities of nitrocellulose should be produced.

The phenomenon known as "firing" of guncotton causes, after a short but moderate liberation of acid, clouds of red fumes, and the only effective remedy against this is immediate removal of the staff.

The explosion of nitrated cotton liberates fumes, the toxicity of which may be compared to those of carbon monoxide.

**Statistics**

Cases of poisoning from nitrous gases are comparatively frequent; they were particularly frequent during the war, when explosives were manufactured in increased quantities. A section of the Trade Association in Germany, including Baden, Wurttemberg and the Rhenish Palatinate, with an average of 33,000 members working full time, made the following returns of industrial poisoning cases:

<table>
<thead>
<tr>
<th>Year</th>
<th>By nitrous gases</th>
<th>Deaths</th>
<th>By other poisoning</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1917</td>
<td>15</td>
<td>4</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>1918</td>
<td>15</td>
<td>3</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>1919</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>1920</td>
<td>0</td>
<td>0</td>
<td>31</td>
<td>1</td>
</tr>
<tr>
<td>1921</td>
<td>2</td>
<td>0</td>
<td>31</td>
<td>4</td>
</tr>
<tr>
<td>1922</td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>0</td>
</tr>
</tbody>
</table>

In cases of death from nitrous gases, the death followed mostly on the second day after the poisoning; in one case, however, death did not supervene until the eighth day.

According to comprehensive statistics prepared by Leymann, workers dealing with nitric acid are greatly troubled with corrosions of the skin, and a fairly high percentage of cases of diseases of the respiratory organs are met with amongst them.

**Pathology**

The pathology of nitrocellulose workers is connected with poisoning due to nitrous fumes, carbon monoxide, etc., and with poisoning due to other toxic substances already referred to above under Dangers.

**Hygiene**

Hygienic measures taken in the manufacture of guncotton are in general satisfactory, especially if the process of dipping in troughs is replaced by Selvig centrifugal machines, or even better by the Thompson system of double centrifuges. Oleum (fuming sulphuric acid) at 70 per cent. should be replaced by oleum at 20 per cent. Prevention of clouds of vapour in the shops, where washing in hot water is engaged in, must be effected. Suppression of these is possible when compulsory regulations are complied with. Further, nitrous fumes, in regard to which attempts are generally confined to more or less complete diffusion in the atmosphere, ought to be condensed. The wash basin placed at the exit of the Selvig centrifuges should be protected by a hood communicating with exhaust ventilation. The piping as well as the ventilators should be of stoneware (acid-resistant) and the fumes should be forced into condensation towers. As there is danger that the nitrous fumes are given off at the moment when the nitrated cotton leaves the double centrifuges (Thompson system), and even with a good exhaust installation, it is advisable to provide the workers with respiratory apparatus.

Liquids from centrifugal drying and from condensation of fumes should be withdrawn under an exhaust apparatus and filtered. This latter method is not however generally applied.

It is essential to prevent production of nitrous fumes by taking care that no foreign matters (water, oil) are mixed with the product in course of reaction. Every shock capable of producing a sparking discharge is to be avoided; friction and wearing away of the aluminium cover of the Thompson centrifuge should be guarded against, powdered aluminium being a powerful reducing agent. Precautions against fire should be taken by careful supervision of the plant and adequate maintenance of the heating and lighting system.

Effective measures should be taken to remove cotton dust from the workshops, where sorting and carding are carried out. When drying operations are effected in sections, as for example when using the Pétrie drying apparatus, there is ample production of cotton dust which no system of ventilation can cope with. If, by accident, liberation of acid fumes occurs, the workers must quit all workrooms facing the wind. The use of apparatus a feature of which is the production and maintenance of a partial vacuum in the reaction retorts and condensation batteries, throughout the duration
of the various operations, automatically prevents the diffusion of fumes in the atmosphere. Workers engaged at the ovens should be provided with respiratory apparatus containing oxygen. Instruction of the workers in the dangers to which they are exposed, and in the means of avoiding wrong practices, etc., should be insisted on. Medical examination of workers before engagement and periodically thereafter is essential. Persons suffering from respiratory troubles and especially asthmatic subjects are much more susceptible than others and ought consequently to be excluded from the nitration shops. All the provisions prescribed for explosive factories (see article "Explosives") to combat danger of fire and explosion are of course applicable to nitrocellulose factories (see also article "Celluloid").

LEGISLATION

The legislator treats nitrocellulose simply as an explosive and places it, as regards manufacture, conveyance, packing and storage, under the provisions applicable to explosive substances. For soluble pyroxyline these are often unnecessarily stringent requirements, since, as already indicated, soluble pyroxyline with less than 12 per cent. of hydrogen and a humidity of 30 per cent. is no longer to be regarded as an explosive.

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Prof. Holtzmann
(Karlsruhe).

Nitrogen


PROPERTIES

Nitrogen is a gas found free in the atmosphere (78-80 per cent. nitrogen, 22-20 per cent. oxygen). With other elements, it enters into the composition of ammoniates, nitrates, albuminoid matter, and forms the largest part of animal and vegetable tissues.

Nitrogen (symbol N) is a colourless, inodorous gas having a density of 0.97 (air=1). It is liquefied with difficulty; its critical temperature is —146° C. and its critical pressure 35 atmospheres. In the liquid state it is colourless with a specific gravity of 0.804 and boils at —194° C. It solidifies at —214° C. Only slightly soluble in water, it neither maintains combustion nor respiration.

Nitrogen is a very inert gas which only combines when heated with some metals (lithium, magnesium, silicon, etc.) yielding nitrides (sometimes only in the presence of catalysts).

Under the influence of the electric spark it combines with oxygen, forming nitrogen peroxide (NO₂) (reddish-brown fumes) and, with hydrogen, ammonia.

It is produced pure if ammonium nitrite or a mixture of sodium nitrite, ammonium sulphide, potassium chromate, and water are heated. Indirectly it can be obtained from liquid air by conversion of this into a gas in a rectifying apparatus; under these circumstances it is almost pure (99 per cent.), generally the industry using it produces it as required; this is also the case with ammonia, calcium cyanamide: for filling lamps and electric torches, etc.

Nitrogen is not toxic; but, as has been said, it neither supports combustion nor respiration.

COMPOUNDS OF NITROGEN

Among the five hydrogen compounds of nitrogen the most important are ammonia (see that article) and hydrazine (N₂H₄), prepared by the action of sodium hypochlorite on ammonia. Chloramine (NH₂Cl) is first obtained and, at low temperature and under a vacuum it distills, in the form of oily drops. By fractional distillation of the aqueous solution the hydrate of hydrazine (N₂H₄H₂O) is obtained — a very strong base, recalling soda-lye and acting like a caustic. But it is of no interest from the practical point of view for industrial hygiene.

Among the halogen compounds nitrogen chloride and iodide should be mentioned, and among the oxygen compounds the protoxide (N₂O) or laughing gas which has no irritant action; nitric oxide (NO), the trioxide or nitrogen anhydride (N₂O₃), the nitrogen dioxide (NO₂), the peroxide (N₂O₅), and nitric anhydride (N₂O₅).
Legislation

Regulations apply as in the case of nitric acid, ammonia, etc., the chemical industry, nitro-derivatives of benzene and its homologues, etc.

Nitroglycerine is to be treated as an industrial disease.

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Nitroglycerine

(Trinitroglycerine)


Properties

Nitroglycerine, discovered in 1847 by Sobrero, who named it "pyroglycerine" or "glycerine fulminante", is a trinitrate of glycerine, the formula of which is:

\[ \text{CH}_3\text{O} \cdot \text{NO}_3 \]
\[ \text{CH}_2\text{O} \cdot \text{NO}_3 = \text{C}_3\text{H}_3 \cdot (\text{ON})_3 \]
\[ \text{CH}_3\text{O} \cdot \text{NO}_3 \]

In its pure state it is a dense oily almost colourless and inodorous liquid with a specific gravity of 1.66 at 15°C. Its taste is sweetish and burning. The technical product has a colour varying from clear yellow (white wine colour) to a brownish yellow. Nitroglycerine evaporates even at 50°C, and if it is gradually heated to 100°C it commences to decompose, giving off brown nitrous fumes (oxides of nitrogen). Below 13.5°C it solidifies (congeals); it is readily soluble in most organic solvents; it is on the other hand almost insoluble in water, carbon bisulphide and mineral oils.

Nitroglycerine itself is a good solvent, especially for some kinds of nitro-cellulose. It then forms stable colloids (gelatine).

When nitroglycerine contains no acid it does not decompose of itself; it is very stable and ignites with difficulty; it cannot even be lighted by contact with a piece of burning wood or even a gun-powder fuse. In small quantities, nitroglycerine burns slowly, making a crackling noise and with a greenish flame. There is danger of an explosion if it begins to boil while it is being heated.

Nitroglycerine explodes violently when heated to 250°C. with violent percussion or with energetic detonation. In accordance with its chemical composition, nitroglycerine is the most violent of all known explosives. When it is in a congealed condition it explodes more easily than when in a liquid state.

On explosion one litre gives 1.298 litres of gas, which, at the temperature of explosion, occupies 10.4 litres of space. Carbon dioxide, water, nitrogen and oxygen are formed as products of the explosion. This fact is of great importance so far as the use of nitroglycerine as an explosive is concerned, because in the fumes which form after an explosion no strongly toxic gases are found as is the case with other explosives (carbon monoxide, nitric oxide).

INDUSTRIAL OPERATIONS

Nitroglycerine is prepared from glycerine for dynamite manufacture, a product of very high concentration and the greatest purity. This condition is extremely important from the point of view of safety in manipulation.

The acid mixture is obtained by slowly adding sulphuric acid (96 per cent.) to nitric acid (98 per cent.) contained in iron receptacles, cooling and agitating strongly; for 100 parts by weight of nitroglycerine, 240-270 parts of nitric acid and 330-360 parts of sulphuric acid are needed. The best results seem to be obtained with a nitro-sulphuric mixture of 46 per cent. of the first and 54 per cent. of the latter.

Nitrification

This operation is considered one of the most dangerous in the chemical industry. In order to render it free from danger, the personnel must be perfectly conversant with the work and exercise meticulous care.

The nitro-sulphuric mixture in the desired quantity is received into an upper reservoir of the apparatus for nitrification of the glycerine. The apparatus made of lead is surrounded by a wooden envelope (not of iron because of the danger of sparks set up by violent contact, etc.); water circulates in between, as well as in the serpentine coils of lead applied against the internal wall of the boiler. The apparatus is closed and furnished with a duct serving for the escape of air and for the withdrawal of the intense fumes which are recovered in small condens-
Fig. 92. — Scheme of the installation of a nitroglycerine factory.

T. Peat filter.
Z. Underground passages.
W. Raised embankment.
N. Nitration room.
NB. Nitrating apparatus.
SB. Decantation apparatus.
S. Safety apparatus.
D. Vent pipes to carry away fumes.
K. Condensing apparatus.
U. Refuges.
B. Acid reservoir.
NS. Decantation.
A. Decantation apparatus.
R. Washing.
G. Washing apparatus.
F. Filters.
I. Labyrinth.
The acids of nitrogen comprise hypo-
nitrous acid (H₂N₂O₃), nitrohydroxylic
acid (H₂N₂O₄), nitrous acid (HNO₂), nitric
acid (see that article), etc., and nitric
anhydride (HNO₃).

Various nitric salts are prepared by
dissolving the corresponding substance in
nitric acid. In this reaction nitrous fumes
are given off. When a mixture of nitric
and hydrochloric acids is used to dissolve
certain metals (gold, platinum) chlorine
is evolved.

\textit{Nitrate of barium} \[\text{Ba (NO₃)₂}\] is used for
producing a green colour in fireworks and
in the preparation of certain explosives; \textit{nitrate of stromatium} for red
colours; \textit{nitrate of ammonium} for explosives; \textit{nit-
trate of lead} is used in dyeing, in textile
printing, in the preparation of chrome
yellow and other lead compounds; in the
paste for matches (danger incurred from
nitric acid, nitrous fumes and lead); \textit{nit-
rate of iron} also is employed in dyeing
silk black, as is also \textit{nitrate of copper}.
It is well known that nitroglycerine to which \textit{nitrate of mercury}
is put, see the articles \textit{"Hatters Furriers Processes"} and \textit{"Haircutting"}.

\textit{Nitrate of sodium} is manufactured indus-
trially in large quantities for use in the
preparation of dazo compounds, with the
nitrate as the starting point and the addi-
tion of lead or iron. These latter act as
the reducing agent and when lead is used
the worker is exposed to the risk of lead
poisoning. Many such cases have been
reported in the course of manufacture of
nitrates in Russia. \textit{Nitrate of amyl}, the
vapour of which may cause palpitation
and congestion in the head, etc., has
caulsed many serious cases of intoxica-
tion (Egili-Rust).

\textit{Nitrate of ethyl} in 1921 also caused cases of
poisoning in a Bavarian chemical
works. The symptoms were as follows:
fainting, slow reaction of the pupils,
cyanosis, rapid heart action. On recover-
ing consciousness the patients showed
signs of irritability, spasmodic muscular
movements (in the limbs), faintness, etc.

The oxides of nitrogen are given off
when nitroglycerine, dynamite, etc., are
burnt or exploded in mines or confined
spaces. Thus, according to Haldane, nitro-
glycerine gives off 62 per cent. of carbon
dioxide and 31.6 per cent. of nitrogen;
when it burns in the presence of its own
gases 33.9 per cent. of carbon monoxide
and 48.5 nitric oxide which, in contact
with air immediately oxidises, forming
red fumes (nitrous fumes). Peroxide of
nitrogen is perhaps the most irritating of
all the oxides of nitrogen. The symptoms
come on some hours after the destructive
action on the mucous membrane of the
respiratory tract (see article \textit{"Nitrous Fumes"}); bronchitis and pneumonia are
frequent sequelae.

\textbf{TOXIC ACTION}

The experiments of O. Girndt and E.
Le Blanc on the action of the protoxide,
both in the case of animals and man,
showed that air containing 1.2 to 16 per
cent. (in animals from 0.5 to 80 per
cent.) had no effect on arterial pressure,
as had been admitted by Kestner.

Inhalation of the dioxide and per-
oxide has occasioned numerous acci-
dents in factories and laboratories
dipping metal articles, manufacture of
sulphuric acid, nitrate of mercury,
etc., with several fatalities (see article
\textit{"Nitrous Fumes"}).

In contact with air the nitric oxide is
quickly converted into the peroxide, so
that it is the latter gas which acts or,
at any rate, a mixture of the two.

Where pure, the nitric oxide is a co-
avourless easily liquefiable gas, which
dissolves in water (to the extent of one-
twentith of its volume) and combines
directly with oxygen to form the per-
oxide: it supports the combustion of
phosphorus, etc. Generally it contains
considerable quantities of the protoxide.
Davy tried to breathe nitric oxide
directly having been careful first to fill
his lungs with the protoxide to avoid
the oxidation of the nitric oxide. Davy
experienced a violent spasm of the
air passages and constriction in the glottis
and had to give up. In all probability, however,
partial oxidation at least of this gas
does take place in the lungs (Kohn-
Abrest).

Nitrogen has not, like oxygen, the
cpower of combining chemically with
the blood.

Hermann, who has described the ac-
tion of nitric oxide on the blood, ad-
mits that combination of the haemo-
globin with it does take place and that
the affinity between the two is so great
that it can displace the carbon mon-
oxide from its combination with
blood. The absorption spectrum of
NO-haemoglobin is not characteristic.
Ogier noted the ordinary spectrum of
oxyhaemoglobin, but the absorption
bands were very weak. After the ac-
tion of the sulphide this spectrum
resembled that of a specimen of oxy-
generated blood containing a very small
quantity of carbon monoxide. Kohn-
Abrest is of opinion that this cause of
ever is very rarely likely to occur in
testing.

At the same time the combination of
compounds of nitrogen with haemo-
globin has been recently studied (1926)
by Haldane, Banham, and Savage.

These authors are of opinion, that cer-
tain post-mortem findings, simulating
very closely those of carbon monoxide
poisoning, are due to the formation of
nitric oxide haemoglobin after death.
This opinion, which, however, does not
meet with acceptance by all writers,
especially not in Germany, deserves to
be given in full.
The findings in the case of a collier, whose death followed on stoking boiler furnaces, closely resembled those to be expected from carbon monoxide. But an analysis of all the facts of the case showed conclusively that the sole cause capable of imparting a red colour to the blood as well as of setting up other reactions — once the action of carbon monoxide was excluded was nitric oxide haemoglobin. This compound, discovered by Hermann in 1865, is formed when nitric oxide is brought into contact with reduced blood.

The colour of the blood changes at once from dark purple to the bright scarlet as shown also by blood saturated with oxygen or carbon monoxide.

A double-handed spectrum, similar on the whole to that of oxyhaemoglobin or CO-haemoglobin, appears at the same time. The bands are, however, much less sharply defined than those of oxyhaemoglobin, and somewhat less sharply than those of CO-haemoglobin. The NO-haemoglobin band in the yellow extends, also, to a slight distance on the red side of the D line. On great dilution with water the oxyhaemoglobin solution appears yellow in daylight, while CO-haemoglobin appears pink; this difference affords by far the simplest and most delicate means of detecting the presence of carbon monoxide in blood. NO-haemoglobin gives a tint which is pinker than that of oxyhaemoglobin, but not nearly so pink as that of CO-haemoglobin. The solution of NO-haemoglobin can be distinguished at once by boiling, since it gives a pink coagulum, while oxyhaemoglobin and CO-haemoglobin give a dull grey coagulum.

This difference is due to NO-haemochromogen, which is stable in the boiling water and of a red colour. In other respects, NO-haemoglobin gives similar reactions, including spectroscopic ones, to those given by CO-haemoglobin.

NO-haemoglobin and its products are very familiar. Haldane in 1901 showed that the red colour of raw salted meat is due to the presence of NO-haemoglobin, while the corresponding pink colour of cooked salt meat is due to NO-haemachromogen. The nitrite used in salting the meat becomes reduced in the meat to nitrite and in presence of the reduced haemoglobin, which is also there, the nitrite becomes further reduced and the resulting NO combines with the reduced haemoglobin to form NO-haemoglobin.

It had already been shown by Haldane, Makgill, and Mavrogordato that in animals which have been killed after receiving a dose of nitrite the blood becomes bright red after death in consequence of the formation of NO-haemoglobin; and the possibility of this being taken for CO-haemoglobin was pointed out at the time.

When nitrite is given to a living animal methaemoglobin is formed. Not only, however, is this the case, but a certain amount of NO-haemoglobin is also formed. The colour of the blood solution treated with nitrite is therefore reddish brown, in contrast to the dull brown of pure methaemoglobin. The contrast in both colour and spectroscopic appearance becomes much more evident on making the solution faintly acid by shaking it with expired air.

On reducing the methaemoglobin with ammonium hydrosulphide, the whole of the haemoglobin passes very gradually into NO-haemoglobin, or, on boiling the whole, passes rapidly into NO-haemachromogen, so that the coagulum is pink.

Nitrites poison an animal by depriving the haemoglobin of its oxygen-carrying power, just as CO does; but the animal has a cyanosed appearance, contrasting with the red colour in poisoning by CO.

The cyanosis is not due to the presence of reduced haemoglobin, but to that of methaemoglobin.

It is suspected that infected microorganisms producing nitrite from the body, such as, e.g., the influenza bacillus, may readily account for the presence of NO-haemoglobin post mortem.

From the medico-legal standpoint, therefore, the possible presence of NO-haemoglobin must now always be considered in cases of suspected CO poisoning. The distinction can be made with great ease by boiling a watery solution of the blood. If the red colour and other corresponding chemical reactions or spectroscopic appearances are due to NO-haemoglobin the coagulum will be pink.

According to Kohn-Abrest, very little information exists as to the effect of nitrogen protoxide on the blood.

However, extraction of this gas in the blood under a vacuum is not difficult and the amount of gas recovered from persons who have been asphyxiated by it is pretty considerable and consequently easy to recognise.

HYGIENE

See articles "Nitric Acid", "Ammonia", and "Chemical Trades".
The control of the temperature of reaction is carried out by means of thermometers placed in the vat at varying levels and connected up with automatic alarums. The bottom of the nitrating apparatus is provided with one or two large earthenware taps for rapid emptying, in case of danger, of the mass into a safety basin filled with water ("drowning" of nitroglycerine), which is below the apparatus and which has a capacity of about fifteen times the latter. An earthenware pipe, similarly provided with automatic closing apparatus, leads to the decanting apparatus. The glycerine is introduced into the acid mixture in several tiny jets, while stirring is effected by means of dried compressed air which bubbles through the reacting mass and maintains an even mixture. In general the temperature of the reaction is about 25°C. The course of the nitration is effected without danger when constant control is kept over the cooling arrangements. As a matter of fact, if a few drops of cooling liquid (generally a brine of magnesium chloride) were to penetrate into the mass and make it heat up rapidly, there would be danger of immediate decomposition and explosion of the nitroglycerine. This is why the brine circulates in the coils at low pressure, in order that it should not reach the mass, where it would cause an escape into the piping.

Maintenance of the apparatus and coils is controlled at least once daily and always in the evening. Finally, cylinders of compressed air should be kept in reserve or bottles containing nitrogen or concentrated carbon dioxide in case something goes wrong with the compressed air apparatus.

Decantation

When the operation is finished, nitroglycerine, the specific weight of which is less than that of the acid mixture, floats on the top of this and is separated by decantation. This apparatus is made out of a leaden vessel, with the bottom sloping towards the centre and supported by a wooden armature communicating above by means of a pipe with the vessel for washing. The tube in the centre of the bottom of the apparatus communicates with two or three taps and is provided with a glass window. One of the taps discharges the acid. The separating line of the two layers coincides almost with the tap placed in the centre of the side wall of the apparatus, which allows of the almost complete discharge of the nitroglycerine into a wooden reservoir lined with lead.

Secondary Decantation

The apparatus for secondary decantation is cylindrical in shape and has at the top a glass fixture with a tap and a glass window. It is made of lead and enclosed in a wooden box. The acid mixture remains for several days in this apparatus and the nitroglycerine, which is collected by mechanical means, rises gradually in the tube and is then discharged into the washing vessel.

Fig. 43.

H. Wooden envelope.
B. Leaden reservoir.
D. Vent pipe carrying off fumes directed towards the condensation installation.
G. Arrival of the glycerine.
Y. Pipe for distributing glycerine
J. Arrival of the compressed air.
R. Pipe for the distribution of compressed air.
S. Entry of the acid.
K. Entry and exit of the cooling water.
T. Thermometers.
F. Observation window.
A. Exit pipe going to the drowning tank.
Z. Glycerine valve.

Washing (Stabilisation)

The nitroglycerine which is contaminated by the acid mixture is delivered by a suitable pipe into receptacles of earthenware half filled with cold water, where it is agitated by bubbling compressed air through it. The nitroglycerine is then allowed to settle; the washing is repeated with water, and then with a very dilute solution of soda (stabilisation), until the washing waters no longer give an
acid reaction and the mass has a very slightly alkaline reaction. The washed nitroglycerine is transported in buckets of hardened rubber or of ebonite to the filters (wooden boxes covered with woollen cloth or felt, sometimes provided also with dried salt to keep back the emulsified water). After washing the nitroglycerine is stored or used immediately.

**Treatment of the Washing Waters**

The washing water still contains nitroglycerine and consequently cannot be run off easily. All the waters used in the operations pass into a single receptacle called the “labyrinth,” which is divided into several chambers by baffle plates, where the slowly flowing water, before escaping at the point opposite to that of entry, is forced to make a detour (up and down) and leaves the drops of nitroglycerine suspended in a state of emulsion. Before being run off, these waters are further passed across a filter made of several layers filled with peat. The last remains of the explosive substance are thus kept back. The peat from the filters is taken up from time to time and burnt with the greatest precautions.

**Denitration**

The acid from the secondary decantation (residual acid) contains not only 70-75 per cent. of sulphuric acid, 7-10 per cent. of nitric acid and 15-20 per cent. of water, but also various nitrous products and impurities of an explosive character (mono-, di- and trinitroglycerine). The sulphuric and nitric acids are recovered by denitration in towers 6 metres high with a diameter of about 1 metre, formed of six or seven Volvic stone rings and surrounded by closely adhering steel rings. The acid flows from above downwards over the filling matter (fragments of silica, glass or earthenware), while a current of steam at 350° C. and hot air at 400° C. passes through the tower from below upwards.

In this manner the organic products are destroyed, the nitric acid fumes escape at a temperature of about 110-120° C., and the sulphuric acid is collected at the base of the tower at about 150° C. The two regenerated products are either concentrated in special apparatus or used in other operations. The denitration is effected without danger if there is a complete separation of the nitroglycerine and the mixture, which can only be secured by providing sufficiently large apparatus for secondary decantation.

**Uses**

Formerly nitroglycerine was used in a very dilute alcoholic solution or in the form of a pastille in the treatment of chronic nephritis, for lowering the blood pressure in arteriosclerosis or for similar objects. Practically all the nitroglycerine made to-day is used as an explosive, in the manufacture of various types of dynamite, explosive gelatine, smokeless powder, etc. Serious accidents from the explosion of nitroglycerine have sometimes led to the prohibition of its manufacture. But the happy solution of Nobel has been able to eliminate the danger by mixing nitroglycerine with inert porous substances (diatomaceous earth) in order to obtain dynamite (see article “Explosives”).

To-day use is also made of cuprene, in the place of diatomaceous earth, as a stabilising agent for nitroglycerine. Freezing nitroglycerine has been suggested as a means for rendering it less sensitive, but this fact is generally contested; in some cases, it has been carried without danger dissolved in ethyl or methyl alcohol. It is re-precipitated with water when it is required for use.

**Poisonous Effect**

Nitroglycerine exercises its toxic action even through the uninjured skin, but it is the mucous membrane that is particularly susceptible to its absorption. On the skin, and especially on the palm and in the interdigital spaces of the hand, nitroglycerine produces eruptions characterised by great dryness and the formation of rhagades.

The workers show ulcers under the nails and at the extremities of the fingers, and these ulcers are very hard to heal (Erben). Susceptibility in regard to nitroglycerine is further increased by alcoholic drink; thus it is for this reason that excessive indulgence in alcohol brings on a state of excitation bordering on mania or confused mental agitation. In these circumstances, fatal cases have sometimes occurred.

The toxic action of nitroglycerine is characterised by headache accompanied by excitement, a feeling of heaviness in the frontal and occipital regions, insomnia with diarrhoea and vomiting in the night. Nitroglycerine
exerts toxic effects when absorbed internally in stronger doses: fainting, vertigo, burning in the oesophagus and stomach, colics, paralysis, slowing of the heart's action, diminution in the blood pressure, respiratory râles, cyanosis, coldness of the extremities and redness of the face have been observed. Apart from these nitroglycerine is a sexual stimulant; in some persons who are particularly sensitive inhalation of a small quantity of the vapour is sufficient to produce an effect.

Work with nitroglycerine leads to acclimatisation, which occurs more or less rapidly according to individual pre-disposition.

A break in the work interrupts this acclimatisation, which has to be re-acquired afresh. In order not to lose the effects of this action, American workers are in the habit of moistening their hat bands with nitroglycerine during any absence from the factory, but the efficacy of this measure seems to be very doubtful in comparison with the risks which it entails.

In the chronic form, intoxication by nitroglycerine shows itself in digestive troubles, tremors and neuralgia. J. Heitz (1924) examined twenty-six workmen and women of average age who were regularly employed for several months or years in the transport and mixing of nitroglycerine with other products or with the filling of cartridges. The commonest complaint was headache, prevalent on commencing work with nitroglycerine but which soon passed off, only to manifest itself again whenever the workman resumed work, even after a suspension of work for hours. The examination of blood pressure enabled Heitz to confirm the fact that it is always lowered when at work while normal in those not at work. The diastolic pressure is always markedly lower than the systolic. Alcoholic persons show increased pressure when not at work and a slight diminution during work, especially of the diastolic pressure.

Another source of danger is present in nitrous fumes, which, in the course of manufacture, are evolved or formed when nitroglycerine explosives are fired. When in small quantity, this gas produces tremor, congestion in the head, vomiting and headache; its presence in large quantities results in vertigo, cyanosis, excitation and loss of consciousness. Respiration resembles snoring, the skin of the hands is cold and the pulse feeble.

When consciousness returns the patient has a feeling of fatigue and headache, the pulse is intermittent. In the case of serious intoxication, the issue may be fatal.

In its liquid form nitroglycerine tends to explode spontaneously with great ease, especially if it contains traces of acid. It is particularly dangerous when it is frozen, because, if it explodes it is not completely destroyed and can set up successive decompositions. The freezing point can be lowered by mixing 25-30 parts of dinitroglycerine with 75-70 parts of trinitroglycerine, or 30 parts of dinitrochlorhydrine or nitroglycol with 70 parts of nitroglycerine. Sunlight exerts a violent effect on nitroglycerine and may cause explosions. In the same way sudden or excessive rises in temperature during nitration may result in explosion by immediate decomposition of the mass. This danger of decomposition is rare to-day and can generally be accounted for by faulty apparatus or inattention during the process of nitration.

SAFETY AND HYGIENE

The manufacture, as well as the manipulation, of nitroglycerine demands the most meticulous care and attention.

Since the reduction of the charge of glycerine to 100-150 kg., the number of factories undertaking manufacture has greatly increased.

To-day, nitration and decantation and washing are not carried out in the same workroom. In this way, if there is an explosion it is limited to a single site. The loss of a single small workroom thus affects production less seriously than formerly, when great expense was incurred.

The manufacturing rooms and storage rooms, etc., ought to be surrounded by an embankment of earth about 1 metre higher than the roofs of the neighbouring sheds. The circumference should be 10 metres at the base and 1 metre at the top. The slopes of this mound should be covered with vegetation to protect the neighbourhood from the debris resulting from the explosion and to reduce the horizontal pressure.

The distance between the sheds ought to be at least 15-20 metres, in order to prevent the propagation of fires or explosions. Access to the buildings through the embankments is made by means of passages with a bend in them or by tunnels walled or concreted; in order to prevent the propagation of explosions two sheds in
which this risk is present should never
be connected by means of tunnels. Care
should be taken, in the store-
rooms especially, in regard to light-
ing; all pieces of metal should be
earthy so as to prevent them becom-
ing charged with static electricity.
Up to the present the sheds have
been generally built of wood, to di-
minish the danger in case of explo-
sion, but this system affords no pro-
tection against the spreading of fires
or the fall of large pieces of debris.
As a matter of fact concrete build-
ings (with no siliceous stones) are to
be preferred, constructed in the form
of a vault open on one side and cover-
ed with an earthen roof.
The apparatus for the production of
nitroglycerine is placed at a very high
point in the workroom, so that, in the
successive operations the product is di-
rected towards the other apparatus,
all situated at a lower level.
When liquid nitroglycerine is being
prepared, or handled, the floor of the
workroom should be covered with
lead plates having raised edges, so
that the material can be collected if
any of the apparatus breaks. In
places where nitroglycerine cakes (dy-
namite) are kept, the floor should be
of closely fitted wood without any
cracks.
If nitroglycerine is accidentally spilt,
it should be mopped up immediately
with a sponge.
Nitroglycerine is fairly easily decom-
posed by an alcoholic solution of
caucus potash and this saponification
reaction is used to destroy and render
harmless where necessary small quan-
tities of nitroglycerine. For the same
reason, solutions of caustic soda are
used for washing the tables or floors on
which nitroglycerine has been spilt.
The piping for the circulation of
nitroglycerine is often gutter-shaped
with a movable cover and provided
with a pipe for the circulation of warm
water in order to avoid freezing in
winter, as that is always a source of
danger. There is a risk, however,
that if an explosion takes place in one
of the gutters it may spread along the
channels to all the rooms; hence it is
useful to detach a piece of the gutter
when nitroglycerine is not circulating.
It is, however, more prudent to trans-
port nitroglycerine in pails of hard-
ened rubber, or ebonite.
The glass in front of apertures
should be whitewashed, as curves in
the glass might act as lenses, and if
light were concentrated on the exp-
losive matter detonation might re-
sult.

For other means of safety see arti-
cle "Explosives".
The preparation and manipulation
of nitroglycerine demand most meti-
culous cleanliness if the workers are
to be protected against the risk of
sickness. All means of assuring
minute personal cleanliness should be
provided: working clothes, caps or head
coverings, etc. The workers should
wash the face, hands and nails and
pass as much of their time as possible
in the open air. All the workrooms
should be provided with a good system
of ventilation.
The treatment of headache due to
nitroglycerine belongs to the sphere of
the medical attendant in charge. It
should be remembered that very strong
black coffee, although not always
efficacious, is nevertheless to be rec-
commended. The medical man
should be called in at once, especially in
serious cases.

LEGISLATION

Statutory provision as to the manu-
facture and use of nitroglycerine is bound
up with legislation on explosives and
makes for diminution or avoidance of the
danger inherent in the irrational manipu-
lation of explosives.
Several countries have laid down spe-
cial requirements for the installation and
production of nitroglycerine explosives:
France, Germany, Great Britain, Italy,
etc.
Illness due to nitroglycerine entitles to
compensation in Finland and Switzerland.

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 f. das ges. Schiess- und Sprengstoff-
 wesen (Munich), etc.

Dr. Fischer
(Berlin)
Nitrous Fumes
(Oxides of Nitrogen)

French: Gaz nitreux. — German: Nitrose Gase. — Italian and Spanish: Gas nitrosti.

CHEMICAL PROPERTIES

Glowing red nitrous fumes — products of the low oxidation of nitrogen — consist of brown or brownish red gases decidedly heavier than air. A litre of protoxide of nitrogen weighs 1.34 grm. Fumes generally consist of a mixture of nitrogen peroxide (or hyponitric anhydride: N₂O₅) and the protoxide (N₂O₃) or dioxide of nitrogen (nitric oxide NO₂) which, however, on coming into contact with air, changes immediately into peroxide of nitrogen. Other compounds of oxygen and nitrogen which may be found in nitrous fumes are nitrous anhydride (N₂O₅) and nitric anhydride (N₂O₆); these are less stable than the two compounds mentioned above and, under certain conditions, become transformed into dioxide of nitrogen or into hyponitric acid and also into the peroxide which is the most stable compound of oxygen and nitrogen. Among the oxyacids which may also occur in nitrous fumes are nitric acid (HNO₃), nitric oxide (H₂N₂O₂), and hyponitrous acid (H₂N₂O₂). During certain processes, e.g. in cleaning metal, fumes of oxide of nitrogen arise from solutions containing chlorine and then form nitrosyl chloride.

Nitrous fumes come to be noticed by their reddish-brown colour and irritant action. The protoxide is, on the contrary, colourless; the lower oxides are pale.

SOURCES OF POISONING

As Chief Products

Risk occurs when the nitrogen of the air is oxidised by different processes, among which must be specially noted the oxidation of nitrogen in the electric display arc and the preparation of oxide of nitrogen according to the process of Haber, the starting point for synthetic ammonia.

Oxide of nitrogen obtained by these processes can be used in various ways. The gases freed by an intermediate process may be utilised immediately for the preparation of ammonium nitrate, which is used as a manure, and in the manufacture of explosives; or they are absorbed by water (following the principle of the counter current), the residuary gases being submitted to a fresh absorption; or else the gases are subjected to a cooling process, when the oxide of nitrogen, after being thus dehydrated, is liquefied by bringing it to a very low temperature by means of a refrigerating machine.

Some substance that nitrifies with difficulty is passed through the machine, generally as a cooling liquid (ethane machines are specially used). If the tubes are not quite airtight and if the nitrous fumes come in contact with organic liquids, reactions and even explosions occur, accompanied by liberation of large quantities of oxide of nitrogen. This danger, which has attracted attention owing to a series of small and large explosions, seems to be all the greater in that it is always underestimated by the technical staff, or that it cannot be avoided.

As By-Products

These by-products, which are always unpleasant, are constantly being formed when, in technical processes, nitric acid or mixtures of this acid with sulphuric acid are used and when the operation is accompanied by a strong reduction. It is the case, for example, in all branches of the large and small metal trades when it is necessary to remove oxides from sheets of polished metal (décapage or cleaning).

Oxides of nitrogen may also develop following a disturbance in a process or particular reactions; for example, when nitrination occurs at a high temperature, or in presence of easily oxidised impurities. These gases develop particularly when, in consequence of a break of the receptacles, nitric acid, or mixtures containing it, come in contact with metal or organic compounds. In these circumstances, large volumes of oxides of nitrogen are suddenly formed and it is dangerous to enter the work- places. Rescue work and, particularly, the salvage of materials are both dangerous.

Danger from the setting free of nitrous fumes exists in a large number of industrial operations, among which may be mentioned those where fuming nitric acid is manipulated, such as soaking, mixing, recovery, and transport; as well as in the chemical industry, for the preparation of arsenious acid, arseniate of soda; sulphuric, nitric, chronic and oxalic acids; ammonia and its combinations and salts; nitric acid, by distillation of nitre with sulphuric acid in iron cylinders; nitrate of barium, by dissolving sulphate of barium in nitric acid; nitrate of lead; acid nitrate of mercury; nitrate of silver; soda; explosives; fulminate of mercury; nitrates derived from bidentate and its homologues; chemical manures: celluloid; aniline colours; artificial silk; photographic films; and in the preparation of thorium and cerium. Danger
also arises from the action of: fuming nitric acid on organic substances, such as coal, wood, straw, and textiles; during the making of glass heads, glue, and artificial leathers by the process called "preparation by animal charcoal" (preparation par le noir); in the making of morocco leather; during the making of glass heads, glue, and metales; during the preparation of iron mordants, etc.; and during the construction of tunnels at high altitudes and during work near glaciers in winter.

Oxides of nitrogen are produced in all branches of the metal industry, particularly in cleaning articles of brass, when this material is in small pieces—work which generally falls to the lot of odd temporary workers, indolent and uncomplaining.

For these processes mixtures of nitric acid, kitchen salt and lamp black are used, prepared according to numerous tests and old recipes. When metals covered with oxide are dipped in such mixtures, complex combinations of very irritating fumes are set free, of which nitrosyl chloride is the prototype; such fumes vary much in composition from factory to factory.

Oxide of nitrogen is also a very disagreeable by-product in the first stages of the decomposition of celluloid, that is to say, of the spontaneous combustion of this nitro-cellulose combination. The decomposition takes place sometimes even in the absence of air, between 120 and 130° C., but it most often occurs about 140-150° C. It sets free an irritating, partly brownish-red smoke, smelling of camphor and containing a relatively large amount of oxides of nitrogen. This smoke, when mixed with air, may give rise to very violent secondary explosions, which generally no longer contain detectable oxides of nitrogen.

TOXICITY

Investigations have been made to determine the critical concentrations which cannot be endured for more than some seconds or one minute.

Like nearly all industrial gases, nitrous fumes are not generally pure and contain always their poisonous action in the pure state. Their action depends especially on their concentration and duration of action, although they are generally diluted in the air. Zangger is of opinion that, generally speaking, nothing is known regarding fatal dosage. According to Lehmann, the quantity of nitrous fumes sufficient to cause irritation of the respiratory passages is 0.2 mg. per litre of air. A dose of 0.3 to 0.4 mg. is absolutely dangerous. The higher oxides of nitrogen are probably more poisonous than those which approximate to "laughing gas", N₂O₃.

The investigations of Lehmann and Hasegawa have shown that for animals there is no difference between the action of nitrous fumes and those of other irritating gases. The poisonous dosage is estimated in terms of total nitric acid: 0.1 mg. of total nitric acid per litre of air is scarcely harmful at all; but 0.2 mg. causes quite a strong irritation and is injurious at the end of a certain period. A dose of 0.3 to 0.5 mg. can only be endured for a very short time. A dose of 0.5 mg. kills a cat in 4 hours, but a dose of 0.7 mg. can sometimes be endured for one hour or two. All doses above 0.9 mg. kill animals in one or two hours; a dose of 5.6 mg. has been borne by a cat for five minutes and killed another cat in 10 minutes.

Ronzani, when investigating chronic poisoning, found that a dose of 0.19 mg. was harmless. Lehmann has also recorded that a dose of 0.27 mg. during 7 to 18 days was not dangerous.
Haldane has reported that 0.05 per cent. of nitrous fumes inhaled for half an hour kills mice at the end of 24 hours. This strength has been confirmed by other experts.

From the clinical point of view, some fatal cases result from inhalation of fumes which do not seem very strong. In particular, old workmen have died after exposure to a toxic dose no stronger apparently than those to which they were habitually exposed.

Hudson claims there can be no question of varying degree of susceptibility to caustic vapours; he holds that apparent differences in susceptibility are due to the exposure-risk incorrectly assessed. Nitrous fumes are not of uniform composition. When they contain a high percentage of irritating products, the worker feels at once the effects and imagines he has absorbed large quantities of fumes. But, on the contrary, the most harmful products are not immediately irritating; they only make their presence felt after having penetrated the lungs and reacted with the tissues. It seems, however, that in the case of massive poisoning personal susceptibility can play a part. It is possible to become in some measure accustomed to inhaling nitrous fumes.

Workmen are very differently affected by the oxides of nitrogen. This has been particularly noticed by students during visits to works: some are extraordinarily sensitive, others much less so. Occasionally, especially among workpeople, persons are met with who have an amazing lack of susceptibility to nitrous fumes and boast about it.

Absorption takes place exclusively by inspired air, for oxides of nitrogen form gas, for on contact with water, or moist air, or the moisture of the mucous membranes or liquids of the body, it is converted into nitrous acid (NO$_2$H) and nitric acid (NO$_2$H$_3$). (Researches by Lehmann and Hasegawa, completing those of Lunge and Berl.) These are the acids which act. In the same way toxicological research upon nitrous fumes resolves itself into that of nitrates and nitrites.

Oxides of nitrogen have a local irritating and corrosive action upon the tissues and more especially on the respiratory and digestive mucous membranes. Any general narcotic effect is of quite secondary importance. It is particularly the action on the respiratory passages, extending even to the small bronchioles, which causes death, not directly, but indirectly, due to local phenomena with pulmonary oedema and cardiac weakness.

Most experts consider that the toxic action of nitrous fumes affects the respiratory passages, setting up laryngitis, bronchitis, and pulmonary oedema, rather than the blood, as is supposed by some other experts. The latter maintain that the nitrous vapours pass rapidly into the circulation, and that changes in the blood elements lead to death.

Nitrous fumes have, in addition, an action on the vaso-motor system, analogous to that of nitrates, acting by vaso-dilatation on the blood, making the red blood cells with transformation of oxyhaemoglobin into methaemoglobin, followed by lesions of spleen, kidneys and liver. Finally, in certain cases, as a result of extra- or post-vital reduction processes, nitrated haemoglobin is found in the blood of the victims, the reactions of which might lead to confusion with the haemoglobin in combination with oxygen and carbon (Heubner and Meier).

The practice of industry, however, creates such unique conditions as regards poisoning by nitrous fumes and oxides of nitrogen that it is quite difficult for the medical man who is not up in the subject to guard against
them. Thus, for example, oxides of nitrogen, like a large number of process by-products, are almost always at the commencement of feeble concentration and are hardly irritating. As a rule, in certain industries nitrous fumes are found mixed with air. A slow increase in the concentration of the fumes is scarcely felt, for persons become inured in a remarkable way to this gas, just as to the irritating action of sulphur-rettéd hydrogen. It is this tolerance, assisted by an anaesthetic and narcotic action, however slight, of nitrous fumes, which often very quickly mitigates the cough, but, by so doing, suppresses a symptom of great importance to an early diagnosis of poisoning.

Another difficulty, perhaps the greatest, depends upon the fact that this gas, although producing local irritation, does not always cause severe pains or a sensation of malaise, or any difficulty in respiration, as do most of the known gases, such, for example, as chlorine, fumes of bromine and hydrochloric acid. The local symptoms only become painful and threaten life several hours after exposure, often 10-12 hours and up to 24 hours; but these poisonings by nitrous fumes are all the more dangerous because their first effects often pass unnoticed, a very limited number of workmen, often only one, being exposed to the action of this gas and a long space of time lapsing between the absorption of the poison and the appearance of the first serious symptoms. This latency in poisoning has only been definitely studied in a series of war gases which cause symptoms of serious secondary poisoning after a similar latent period. This period is considerable with phosgene, shorter with diphosgene, and longer with chloropicrine. It is also seen after absorption of ammonia, chlorine and bromine, but does not exist with dichloroethlysulphate.

STATISTICS

The literature relating to nitrous fumes is almost inexhaustible.

The first record of pulmonary oedema caused by nitrous vapours seems to have been made in 1844 by Potl, who described two fatal cases in the burning of a factory where artificial leather was made by the action of nitrate of soda.

Thirty years ago, Duisberg had already drawn special attention to the danger generally presented by nitrous fumes. Since then numerous cases of acute and chronic poisonings by nitrous fumes have been reported, which are almost all classed under the heading "Acute and Chronic Poisonings".

Leymann (Concordia, 1906) pointed out that respiratory diseases, due partly to the action of nitrous fumes, are high in the nitric acid industry (11.8 per cent against 8.8 per cent, among ordinary workers).

In Germany the cases reported by factory inspectors are as follows: from 1914 to 1918, 13 cases of which 11 were fatal; in 1920, 4 cases of which 3 were fatal; in 1921, several cases of which 2 were fatal. Further, in the reports of factory inspectors, numerous cases have been reported, in Prussia particularly, but no figures are given.

On the other hand, a section of the Trade Association of the Chemical Industry in Germany, including the Free State of Baden, Wurttemberg and the Rhinish Palatinate, with an average of 300,000 active members, gives the following figures for cases of industrial poisoning by nitrous fumes:

<table>
<thead>
<tr>
<th>Year</th>
<th>Nitrous vapours</th>
<th>Other causes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>Deaths</td>
<td>Cases</td>
</tr>
<tr>
<td>1917</td>
<td>18</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>1918</td>
<td>18</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>1919</td>
<td>4</td>
<td>1</td>
<td>77</td>
</tr>
<tr>
<td>1920</td>
<td>-</td>
<td>-</td>
<td>27</td>
</tr>
<tr>
<td>1921</td>
<td>2</td>
<td>-</td>
<td>31</td>
</tr>
<tr>
<td>1922</td>
<td>3</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>9</td>
<td>184</td>
</tr>
</tbody>
</table>

Death from nitrous fumes occurs for the most part two days after the poisoning. In one case death only occurred at the end of the eighth day.

In Austria, from 1914 to 1918, 11 cases were reported of which 4 were fatal.

In France, Courtois-Suffit abstracted 9 cases in 1913, of which 6 were fatal, from medical literature from 1822 to 1906; 2 fatal cases occurred in a gunpowder factory in 1907. Slight affections are less rare.

On the other hand it has been observed that workmen, considering alcohol as an antidote, take an excessive quantity of it; from whence arises a frequency of tuberculosis. Statistics published from 1899 to 1904 show a mortality from tuberculosis twice as great in workshops where nitrous fumes were set free. Sanitary conditions have advanced since 1907, workshops having been improved and better ventilated. In one gunpowder factory in 27 years only 2 cases were reported of pulmonary congestion and some cases of bronchitis of very short duration and not serious.

In Great Britain the reported cases of poisoning by nitrous fumes are as follows:
Most of the cases were reported from nitric acid works or from nitration processes of chemical products or explosives.

In the Netherlands one fatal case was reported in 1917 and another in 1919.

In Switzerland the reported cases are analysed as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases of poisoning</th>
<th>Fatal cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1914</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>1917</td>
<td>62</td>
<td>5</td>
</tr>
<tr>
<td>1918</td>
<td>37</td>
<td>7</td>
</tr>
<tr>
<td>1919</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>1920</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>1921</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1922</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>1923</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>1924</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>1925</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>1926</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>1927</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1928</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

In the United States, in her study on industrial poisonings in the explosives industry, Hamilton reported 1,389 cases of poisoning by nitrous fumes, of which 28 were fatal. The workers affected were employed in the following operations: the manufacture of gun-cotton, picric acid, nitrotoluene, nitrobenzene, nitronaphthalene, nitroglycerine, and in the handling of nitric acid required for these processes.

The nitration of cotton to make nitrocellulose and of phenol to make picric acid present the greatest dangers of poisoning by nitrous fumes; the nitration of glycerine the smallest danger. Between these two extremes are placed the making of nitric acid and the nitration of toluene, benzene, naphthalene, aniline, chlorobenzene and dimethylamine.

According to Hamilton, high industrial mortality caused by nitrous fumes set free in the making of nitrocellulose and picric acid is due to faults in technique.

Slight cases are very frequent at a warm temperature in a heavy atmosphere and do not attract attention. According to Hamilton, in one gun-cotton factory in 1916, during a very warm summer, out of 300 workmen employed, there were each day 20 slightly poisoned, but able to return to work the same day, or even the same night. In another factory with an effective list of 600 men, there were each month, from June to September, an average of 57 cases of poisoning by nitrous fumes.

In the summer of 1916, Irving reported some cases of poisoning in mines, and Czaplewski a considerable number of cases on board warships, when smokeless powder was fired in confined and insufficiently ventilated places.

**Symptoms**

Illness produced by the inhalation of nitrous fumes is always an acute happening. Although this gas may be disagreeable to breathe even in the smallest quantities, it is nevertheless respirable and more especially so when it is strongly concentrated (Curschmann).

If should however be stated that there is no connection between the quantity of nitrous fumes breathed and the seriousness of the affection.

On first inhalation there is a feeling of oppression more or less painful, rarely with thoracic pains, violent spasmodic cough in asphyxiating paroxysms, with a feeling of suffocation in serious cases, which resembles an attack of bronchial asthma.

Inflammation of the larynx has caused such serious symptoms that tracheotomy has been necessary in two cases out of seven.

Removal of the affected person to the open air, and administration of some

![Fig. 44. — Action of nitrous fumes on teeth.](image-url)
NITROUS FUMES

drops of chloroform in warm water, may ease or cure the spasm; and the individual, restored to health, is able to return to work at the end of a day or two if no bronchial or pulmonary lesion arise.

There is a less common form of poisoning which is so rapidly fatal that it does not cause any anatomical changes. In these cases (of Apfelbach and Hamilton, etc.) the poison acts directly and especially on the respiratory centre.

In serious cases the onset is identical; then the respiration becomes normal and all danger of poisoning seems to have disappeared. This apparent state of good health, which is quite pathognomonic, owing to pulmonary changes, and partly toxic, owing to the nervous system being affected; orthopnoea develops with a state of anxiety, and a spasmodic and fatiguing cough. Congestion of all branches of the respiratory tree rapidly sets in with pulmonary oedema accompanied by very abundant expectoration of liquid mucus of a yellow or yellowish-red colour. The pulse is increased, rapid and fleeting; blood tension is low, sometimes even to a dangerous degree, following on vaso-motor paralysis caused by dioxide of nitrogen.

The loss of water, which is serious, causes an increase in the viscosity of the blood; and this with other factors, such as cardiac weakness and pulmonary oedema, establishes in the days which follow a condition which leads to death.

Digestive troubles are also observed: keel is thirst, nausea, very violent colic accomplished by diarrhoea and vomiting.

The temperature is sometimes raised. The blood is brownish-black of a chocolate colour, and will not allow the serum to separate. The presence of methaemoglobin can be detected by the spectroscope. The urine contains albumen and serumglobulin.

The aspect of the sick person is characteristic in serious cases: anxious expression, pallor, bloodshot eyes, cyanosis of the lips, which rapidly develops, and cold extremities.

From the clinical point of view, certain symptoms may predominate and give to the disease a special aspect: thus a digestive, a nervous, and a pulmonary form may be described.

In serious, but not immediately fatal, cases, bronchitis or lobar pneumonia of a common type is often found, and may cause a fatal result at the end of five days and even of two weeks, especially when a latent pulmonary lesion previously existed.

Sometimes also relapses are seen occurring on the threshold of an apparent cure, in the first two or even three weeks after the attack. This development of a late pneumonia which may end fatally is very important from the medico-legal point of view.

Among the sequelae of poisoning by nitrous fumes chronic pulmonary lesions have been reported, also cardiac irregularity with sclerosis of the heart (Curschmann), an increase following a decrease of the heart's activity, an irregular pupil, paralysis of the eye muscles, nervous or trophic disturbances, secretory troubles, anaemia, and wasting.

Chronic poisoning caused by the absorption of small quantities of nitrous fumes is not common. According to Zangger, chronic poisoning by nitrous fumes can scarcely be distinguished from chronic catarrhal bronchitis and is classified under the head of bronchitis. Extensive statistical investigations have not yet been made at all establishments where nitrous fumes are used, but where they have been made the data risk loss of accuracy from the personal equation on the one hand, and rapid changes in personnel (labour turnover) on the other.

Workmen exposed to nitrous fumes suffer from a serious condition of the teeth (see articles "Nitric Acid", "Hair-Cutting Work"). When using copper as a mordant, for example, nitrous fumes cause among workmen a greenish coloration of the teeth with a metallic lustre (Teléky).

The mucous membrane does not escape the injurious effect of the fumes: inflammation and ulceration of the mucous membrane of the mouth, of the nostrils, and of the conjunctivae have been observed, even in workshops where only small quantities of the fumes are liberated.

According to certain experts, mild illnesses attributable to nitrous fumes are quite frequent, and a general weakening of the system attributable to pulmonary or blood changes ought even to be recognised.
Diagnosis

Diagnosis must depend largely on knowledge of the occupation of the sick person, previous history and the symptoms. The latent period is pathognomonic but this fact frequently also causes errors of diagnosis. A medical man cannot always know the relation of time existing between the work and the illness. Further, he forgets that this latent period, more or less long, is characteristic of poisoning among mankind, even though it would seem to be in opposition to experiments made upon animals.

Zangger has reported that in the small trades they always employ only one man on dangerous work and sometimes only for some hours a day, the worker in question being never either accustomed to or familiar with the danger. So we can understand that when these workmen fall ill it is only a question of a short time that the doctors do not ordinarily think of poisoning and see only a sick person who was taken ill at home, generally in the middle of the night; it happens in a number of cases that the man is living alone. Zangger relates this type of cases: "A workman does not answer when called in the morning. He breathes deeply and groans. He has coughed during the night and there is in the chamber vessel a certain quantity of a brownish-red liquid and froth." The doctor sent for later in the morning arrived when the workman was already dead. He diagnosed poisoning by carbon monoxide simply because the dead man was the day before a young man in perfect health. The police requested the opinion of a medico-legal expert, who made the following observations: absence of carbon monoxide in the blood; intense yellow coloration of the hands, the hairs of the nose, the nostrils and forehead (sign of handling nitric acid). The records and an enquiry into the conditions of work showed that this workman, who was employed in a small factory where incandescent mantles were made, had (on the previous day for the first time) the task of dipping all day large quantities of brass into nitric acid. He was not aware of the danger; the ventilation was very defective and at a certain stage in the operation such a large quantity of oxide of nitrogen was set free that the workman had to leave the place for a short time. The workman left the factory before the end of the day's work complaining of pains in the chest.

In other cases it is no use expecting to detect chemically the oxides of nitrogen. However, the liquid expectorated during the night gave with diphenylaminosulfonic acid a characteristic coloration of oxides of nitrogen. In other cases Zangger did not find this coloration. Very often this determination is of capital importance for the worker or the survivors. In fact, it is evidence of an outside influence independent of the will of the person and unavoidable, developed in an exceptional manner during work time. It is, as it is seen, the full explanation of the illness. But medical practitioners do not notify such cases on the ground that it concerns a poisoning.

What is at the root of such errors is the fact that individuals affected are generally still able to return to their homes and only fall sick during the night.

Another personal observation of Zangger, distinctly more complicated than the preceding, shows how oxides of nitrogen may be overlooked by various experts:

A doctor examines a workman who coughs and shivers a little. The patient looks ill and has pulmonary emphysema; the border of the lung is lower to the extent of the width of the hand than when the same doctor made a previous examination. The workman, who had returned home without feeling any particular trouble, said, however, that his illness was due "to ras" and, as he could only speak with difficulty, the doctor assumed it was a simple poisoning by illuminating gas, that is to say, by carbon monoxide.

The illness subsided, and on the fourth or fifth day he went to his parents' home, a railway journey of four to five hours. He had a note to the effect that he was "ill in consequence of the absorption of carbon monoxide during work." The doctor who visited him, trusting the opinion of the first, naturally accepted the diagnosis given in the note, when death occurred ten days after leaving work. The doctor who made the autopsy did not pay much attention to signs of bronchitis and to definite foci of slight broncho-pneumonia, while the chemist who examined the blood sent without other indications, and who did not know the date of this blood, claimed that he found carbon monoxide in one of the three tests made by means of a hand spectroscope.

In a general way no one would wish to undertake a revision of opinions given by five different experts, who all by means of perfectly independent methods had diagnosed carbon monoxide.

However, although carbon monoxide had been detected in one of the three tests, it was not proved that it came from the factory, since the patient had survived ten days. That rather showed a source of carbon monoxide existed near
the place where he had passed his last night, that is to say, at his parents' home.

These considerations led the medical expert to compare all the reports, and that enabled him to establish that at the onset the symptoms were not at all those of poisoning by carbon monoxide; that two absorption bands resistant to sulphuric acid in ammoniacal solution did not show carbon monoxide in the blood. A minute investigation showed that it was impossible that carbon monoxide had been absorbed during the last five days (this had also been noticed by the chemist). The worker in question worked in a large stereotype plate factory, where during the whole day he had to engrave by means of a mixture of nitric and sulphuric acids and of lampblack, without any arrangement for the removal of fumes. This working engraver was an old man; short-sighted and hunchbacked; he had then in doing his work breathed more fumes than a man holding himself straight and having good sight.

On the contrary, sometimes, but much more rarely, poisoning by nitrous fumes is diagnosed when it is not the case. That arises from nitrous fumes being much less known in their properties, possibilities and action, than the only, or nearly the only, poisonous gas which is discussed in clinics, viz. carbon monoxide.

Differential diagnosis is concerned with such as products which, although different from the chemical point of view, have a similar symptomatology, e.g. phosgene, carbon monoxide, ammonia, compounds of cyanogen, dimethylsulphide, the halogenes, acrolein, and with organic products containing nitro groups, as for example, nitroglycerine, mono- and di-nitrobenzene, picric acid, and nitrobenzene.

Detection

In the Air

The characteristic behaviour and estimation of nitrous fumes depend, in the main, on the presence of peroxide of nitrogen and nitric acid. A method devised by Robertson and Napper which gives good results for the estimation of small quantities of peroxide of nitrogen (0.05 per cent.) in the air requires a precise spectrosopic apparatus of delicate adjustment; it is not applicable to the investigations of industrial hygiene.

The classical process of absorption by means of ferrous sulphate is only of practical use for gaseous mixtures containing relatively large amounts of nitrous fumes. It is better to propose to use indirect, but more simple, processes. Among the various methods planned to this end, it is better to choose the ultra-sensitive colorimetric, e.g. for nitric acid and the nitrates, the reactions of diphenylamine, of potassium iodide with starch, of amidobenzoic acid, of metaphenyldiamine, or the formation of a dinitric salt under the influence of a mixture of nitric and hydrochloric acid; for nitric acid and nitrates can be detected colorimetrically the decolorisation of indigo, of diphenylamine, of phenol and sulphuric acid.

A certain number of these methods are applicable to both nitrous and nitric acids, especially those which are very sensitive, e.g. the reaction of ferrous sulphate, and of sulphate of metaphenyldiamine, which detect a mixture of acid and nitrates.

Lehmann's process consists in collecting the nitrous fumes and oxidising them with a solution of 3 per cent. of oxygenated water. After twenty-four hours' rest, the nitric acid formed is titrated with soda. The air for analysis can also be made to pass through a solution of iodide of potassium, when the iodine set free is titrated with hyposulphite of soda. The results are expressed in nitric acid. A cubic centimetre of decinormal solution of iodine is equivalent to 0.2 grm. of nitric acid.

Hébert and Heim have stated that the processes based on the estimation of nitric acid are inapplicable and they have suggested a very sensitive method, of which the limit of absolute sensitiveness is about 0.003 mg. of peroxide of nitrogen (nitrous fumes) per litre of air. The method of working is as follows: a fixed volume of the air for examination (generally 1 litre) is made to pass by aspiration into an absorption tube containing 10 cc. of a 5 per cent. solution of potash. The tube is emptied and rinsed carefully at the laboratory; the fluid which is collected is increased to 500 cc. in a graduated vessel and in a test tube 1 cc. of this homogeneous solution is mixed with 5 cc. of the sulphate of diphenylamine reagent (0.2 grm. per litre of pure and concentrated sulphuric acid).

The coloration obtained is compared with a scale prepared in the same way with increasing and known quantities of a standard solution of nitrate of potash. Knowing that 1 grm. of nitrate corresponds to 0.455 grm. hyponitric acid in weight, or 220 cc. in volume, it is possible to work out the proportion of peroxide of nitrogen, i.e. of nitrous vapours, present in the sample of air.

The reaction which is given by all oxidising agents can only be used in the certain absence of other gases or fumes, such as chlorine, bromine, iodine, hydrobromic acid, hydric acid and organic substances.

In the System

It is sometimes necessary to search for nitrous fumes chemically in the blood or the viscera. This investigation belongs to the domain of toxicology; but, in the opinion of Zangger, in many cases it is impossible.
Sometimes it is because the oxides of nitrogen become oxidised, undergo a change, or enter into reactions in the body. At other times these substances are separated and expelled by mucus, mucous secretions and by coughing, so effectively that oxide of nitrogen, or its derivatives, can no longer be detected in the body when serious symptoms occur. The investigation is only possible when the conditions are entirely favourable. In conclusion, testing for, and separation of, the oxides of nitrogen and the products of decomposition have remained impossible up to the present.

**THERAPEUTICS**

The serious danger and consequences of poisoning by nitrous fumes make it essential to discuss certain points of important practical therapy.

First and foremost there does not exist an antidote acting as a neutraliser on these fumes once they have penetrated into the respiratory passages. There never will be any antidote, for very soon after these fumes have entered into contact with the respiratory mucous membrane and have been absorbed therein, the chemical effect makes itself felt and causes disturbances. Therefore, all treatment based on the chemical action of an antidote will be a mistake. The inhalation of oxygen as soon as the absorption of fumes occurs and without waiting for serious symptoms is intended to counteract the impoverishment of the blood in oxygen. If some of the pulmonary tissue remains unaffected, the person may still be saved provided that oxygen is administered until all symptoms of acute poisoning have disappeared.

The cough which fatigues and damages the heart must be eased. Inhalations of fine sprays of water, weak alkalis, etc., cannot be used as a rule, for the workmen do not report sick and appear to be in comparatively good health. The serious symptoms are for the practitioner to deal with. Narcotics must not be used to calm the patient. For some time in industry chloroform (5 to 10 drops in water) was given, and certain managers and experts are still in favour of this treatment, although it is difficult to understand in what way it acts. Some experts, especially Germans, are of opinion that the use of chloroform is not without danger.

Treatment ought to deal particularly with the first serious symptoms which threaten to be fatal. Pulmonary oedema is regarded as the most important. Without entering into details as to the best treatment to adopt, it should nevertheless be said that, while colloidal treatment is still in its infancy, and that depending on chloride of lime or thiosulphate has partisans and opponents, the dynamo-osmotic treatment by means of a solution of glucose seems to be the most rational. When the pulse is still comparatively good, an immediate bleeding is recommended before the injection of glucose. The treatment carried out at the right moment has astonishing and lasting results (Zangger). The withdrawal of blood relieves the heart, the glucose exercises a favourable action on the viscosity of the blood and especially on the activity of the heart.

**HYGIENE**

In industrial processes where the liberation of nitrous fumes is inevitable, it is necessary as far as possible to carry off the poisonous fumes, condense them, destroy them or recover them. In the processes in which the fumes can be eliminated, the risk must be reduced to a minimum.

It has also been suggested to neutralise the nitrous fumes by liberating in the workroom an alkaline gas, such as ammonia, or to vapourise a 10 per cent. ammoniacal solution.

The use of "silica gel" (colloidal silica) has also been suggested as an absorbent for nitrous fumes.

In certain processes the use of hermetically-closed apparatus with exhaust draught insures efficient protection of workers. In other cases the apparatus is such that it is often difficult to carry out the necessary modifications.

Close attention must be given to the airtight condition of the apparatus and of all piping, and to the proper working of ventilators which must of course be made of material resistant to acids.

Some measures are similar to those laid down for sulphuric or nitric acid (see those articles).

The exclusion is called for of persons who have suffered or are suffering from respiratory diseases, and of persons predisposed to diseases of the respiratory passages and the circulation.

The education of the workpeople on the dangers to which they are exposed should be carried out by leaflets or posters, or better still by the works doctor on the occasion of his periodical visits. Posters have been prepared by the Governments of Germany, England, Netherlands, etc.

We give here the English poster published in 1916 (No. 358), and the Dutch poster published in 1919.
ENGLISH POSTER RELATING TO NITROUS FUMES
(Published in 1916, No. 358)

(1) Workers are warned of the danger of breathing brown acid fumes.

(2) Before repairing leaks, or entering, or staying in any part of a workroom heavily charged with fumes, breathing apparatus must always be put on.

(3) When these fumes are inhaled they may cause difficulty of breathing some hours after and serious illnesses.

(4) If these symptoms occur at home, send immediately a doctor and in the meanwhile remain in the open air as much as possible.

(5) If these symptoms occur at work, send immediately for the doctor. Whilst awaiting his arrival the correct treatment is as follows:
   make the patient lie down;
   keep him warm; and
   see that he has fresh air.

   If the face has a dusky colour:
   give oxygen.

   If he is not sick, give him to drink 5 teaspoonfuls of salt in about half a pint of tepid water and repeat the dose until it causes vomiting.

(6) Keep the breathing apparatus close at hand and in working order, for one never knows when it may be required.

DUTCH POSTER OF 1919

(To be posted in the workroom in accordance with section 69, subsection 2, of Labour Act, 1919.)

Advice to Workers who use nitric acid and the nitrates among other mordants for acting upon and cleaning metals:

NITRIC ACID IS A POISON!
BEWARE OF RED FUMES!
YOUR LUNGS ARE IN DANGER!

Red fumes are due to the action of nitric acid on metals and such substances as cotton, oil, petrol, wood, paper, ashes and earth. These brown fumes are extremely dangerous to certain persons. Inhalation even in small quantity may sometimes have an immediate effect; generally they cause serious affections of the lungs.

Danger of poisoning: Everywhere where nitric acid is exposed and in contact with no matter what material.

Symptoms of poisoning: Restlessness, nausea, pains in the throat and chest, gasping, cough, blue coloration of the face. If the nitric acid is breathed for a long time, there is expectoration of blood and yellow coloration of the face.

Prevention: You must avoid inhaling the red fumes. If nitric acid is upset, clear it away with plenty of water; avoid the use of sawdust or any other similar material. If the worker feels any discomfort after having inhaled these fumes, he must cease work as quickly as possible and go speedily to the doctor.

LEGISLATION

As regards the employment of women and children, see article "Gases and Fumes".

Special legislation has been laid down in Germany (Prussia) by the Ministerial Circular of 8 January 1900 concerning nitrous fumes and the measures of prevention for the use of nitric acid, and by the Industrial Association of the Chemical Industry, the rules of which on the prevention against injuries caused by gases and poisonous fumes have been in force since 1 January 1912 (see Part II, § 13, referring to the liberation of nitrous fumes). The Circular of 8 February 1911 of the Prussian Ministry of Commerce and Industry on the construction and management of workrooms for cleaning metals provides measures against the danger of nitrous fumes.

In France the Decree of 13 October 1913 on hair-cutting works (see that article); in Great Britain, in the United States, etc., the rules concerning hygiene and safety in the chemical industry, explosives, etc., wherever there is liberation of gas and poisonous fumes.

Notification of cases of poisoning by nitrous vapours is enforced in Western Australia, Bavaria, France, Missouri (toxic gases), the Netherlands and Poland; compensation is granted in Western Australia, Finland, Great Britain, the States of Minnesota and New York, Queensland, Switzerland and Venezuela.

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Prof. Zangger (Zurich).
Noises

French: Bruits. — German: Lärm. —
Italian: Rumori. — Spanish: Ruidos.

The influence of noises on the health of workers is one of the most important problems of industrial pathology, for it concerns nearly every modern industry. As a matter of fact, there are few industries to which the introduction of machinery has not brought, in addition to radical changes in methods of work, more or less serious disadvantages from noise and vibration. The study of industrial noises is of comparatively recent date, and the increasing interest which it arouses is accounted for partly by the increase in industrial noises, and partly by a better realisation of their harmful effect, and of the waste of energy which they cause.

**Definition**

Noises consist of a more or less rapid succession of sounds, irregular in periodicity and in intensity. Sound properly so called is, on the contrary, uniform, steady, and without variations in its constituent parts. It is an accepted fact that all noises may be referred to pure musical sounds; for they are similarly constituted with regard to intensity, pitch and tone.

**The Character of Industrial Noises**

In industry there are met with:

1. Musical sounds properly so called, e.g. in industries where sonorous metals are beaten, as when copper boilers and other copper ware articles are wrought. However, more or less pure sounds rarely occur alone.

2. Noises properly so called.

3. Vibrations of varying intensity, affecting the ground and the bodies of workers, due to the vibration of machinery. Although these vibrations are sometimes accompanied by the production of fairly loud noises, these noises cannot as a rule be regarded as excessive. Besides, it is often hard to decide at what point noise ceases and vibration begins. The decisive factor is the number of sound waves per second, and it is difficult to decide if it is the ear by itself, or the whole body which detects the sound or vibration.

**Origin of Noises: The Noisy Trades**

Noise in industry is due to the running of machinery and to actions effected by machines; to vibration and din caused by parts of machines that are not well equilibrated; to transmission gear, such as defective driving belts or bad running; to such tools as hammers and saws; and to the manipulation and transport of material.

Peyser classifies the noisy trades as follows:

**Metallurgical trades.**—Smelting and casting, especially settling and removing sand by means of pneumatic hammers; mechanical stamping by steam hammers; rolling, beating and drawing metals; and forge work. But the noisiest work of all is riveting, either by hand or mechanically. In this latter case the hammer may be rigid or movable, and either held in the hand or fixed on a rest. Automatic riveting may be carried out by means of compressed air, steam, or electric power. A different technique, wherein hydraulic pressure takes the place of the blow, is noiseless. The unpleasant conditions that accompany riveting vary according to the method employed, depending on the workman's position, and on augmentation of noise by resonance; according as the work is carried on in the open air or not, in workshops or even inside boilers, reservoirs, and gasometers that are being riveted. The mechanical cleaning of boilers by means of pneumatic picks, delivering 6,000 blows a minute, is also very trying work. The cutting, milling, planing, boring, and drilling of metals, all of which make discordant sounds, must also be classed among noisy operations. The polishing of metals and soldering operations, especially with the electric arc, make a shrill whistling noise; the gas blow-pipe makes more rasping sounds.

These various operations belong to all metal-work industries, but more particularly to the following: copper works, sheet-iron mills, tin-plate works, nail factories, shoe factories, scythes, locks and manipulating old iron for breaking up machinery, boiler works, and ship-breaking yards.

The Bureau of Standards, Washington, in 1926 studied the transmission and absorption of sound by metals used in construction, using a sonorous source acting in frequencies allied to the four average frequencies, all varying: 250, corresponding to most male and female voices; 1,000, corresponding to the highest pitched soprano voice; 2,000 and 3,000 corresponding as near as possible to the top limit of musical sounds. The materials tested were panels of the dry wall treatment, with or without wooden frames, covered with a more or less smooth varnish.

According to the frequency of the sound, the amount of energy trans-
spinning. The noisiest operation is that lose their power of absorption in proportion as the frequency increases. The less absorbent substances, however, corresponds frequency 297.

of a sound incident at a frequency of 2,190, and 33 per cent, of a sound of 25 millimetres, absorbs 04 per cent. thus, for instance, felt, under a thickness
deal with the frequency of the sound; given out by the source, varying with so many ten-millionths of the energy 100,
same
mitted by the sound through the same panel may vary from 1 to 100, between so many thousandths and so many ten-millionths of the energy given out by the source, varying with the nature of the panel.

The absorption of sound in the case of the same substance varies a great deal with the frequency of the sound; thus, for instance, felt, under a thickness of 25 millimetres, absorbs 94 per cent. of a sound incident at a frequency of 2,190, and 33 per cent. of a sound of frequency 297. In the case of some substances the maximum absorption corresponds to average frequencies. The less absorbent substances, however, lose their power of absorption in proportion as the frequency increases.

Textile industries.— Weaving and spinning. The noisiest operation is that carried on by the "beetlers" — workmen who, in the weaving shops and the shops where the preparation and stamping of patterns on the fabric takes place, keep beating the rolls of material with heavy mallets of metal or wood.

In flax spinning the noisiest operations are those of preparation and spinning; mechanical combing and carding are less noisy; bleaching of cotton is also very noisy. In the garment-making industries the sewing machine is an extremely noisy factor.

Felt industry.— The mechanical processes of pulling out and scraping the hair, and also hair clipping, are noisy.

Transport industries. — Especially railways: workers in the workshops, mechanics, stokers, and engine-drivers are all exposed to the din and whistling of the trains, and also to noises from oil engines (Mazout), from which the hum of the combustion is far louder than from coal-driven engines.

Building trade.— Noisy operations are stone-breaking, construction of tunnels, breaking down walls and foundations by use of pneumatic picks, and work on building stone with stone saws.

Other noisy industries are: the manufacture of cement, of earthenware, of refractory goods, of porcelain, and of emery wheels; the wood industry, including sawing, smoothing and planing; flour mills, chemical industries: extraction of oil by pressure; manufacture of India-rubber goods; multigraphing processes, especially those connected with rapid printing presses; telephone work, from the cracking noises in the instrument; telegraphy, from the noise caused by the apparatus and the operators; gunpowder and armament industry: while testing firearms, manufacturing rifles, and testing shooting ranges, without including lesions which occur in the army and navy to officers, non-commissioned officers and men.

Apart from these various sources of noise must be noted, in all industries and in every place, dull noise and vibration of the ground and walls, due to machinery in rapid motion, such as dynamos, motors, and driving belts; and, above all, worn cog wheels. Increase in these noises is due partly to the development of machinery, and also to the fact that modern concrete buildings are first-rate conductors of sound.

Danger of ear trouble is by no means the same for all these occupations, and differences may exist in the same groups. Coppersmiths do not develop deafness to the same extent as boiler makers (Villaret). A case is quoted of a boiler maker's hearing improving when he left his old trade and became a blacksmith (Peyser).

It must also be recalled that there are, too often, inaccuracies and mistakes when designating the occupation pursued. All the workmen employed, say, in copper works, iron works, or a big ship-building yard are not exposed to an equal degree to the noises peculiar to the industry. The differences may amount to a slight effect, or to double, ten-fold, or a hundred-fold effect, and this may go on for years. Besides, in some workshops the noise may be deafening in some places, but quite bearable elsewhere, e.g. in stamping out metal and in factories for stamped metal boxes. The degree of noise so varies according to the machinery that in workshops which are essentially vibrating and noisy, there may be a matter of fact, corners which are tolerably quiet. In boiler making, for instance, those who are most exposed to noise are the young apprentices who help the riveters by holding up rivets from inside the boilers, whilst they are being hammered home. The same applies to the young boys, boiler-scrapers, who go inside boilers in works and on ships to remove the scale.

It is also necessary to mention shops and modern offices; the latter are specially noisy; this is due to several causes; the cost of modern buildings, which makes it necessary to economise as far as possible in space; and new methods of organisation which tend to create a modern central office instead of an office for each department. The number of office machines goes on increasing; there are machines for
typing, calculating, binding, classifying, multiplying copies, and addressing. As in the case of factories, modern buildings are hard and fireproof, and are constructed of concrete in such a way that they do not absorb sounds, which is accentuated by the fact that there are rarely any curtains, hangings, or carpets to deaden the sound. Then again offices may be situated in noisy streets, quiet one day and busy the next. In summer there is the additional complication offered by open windows.

THE EFFECT OF NOISES

The mechanism by which noises are appreciated is still a matter of discussion. According to Helmholz's theory, the organ of Corti vibrates in unison like a resonator; the elements of the inner ear are attuned to various pitches, the low sounds being perceived by the parts of the cochlea that are further from the base than the high sounds by the parts that are nearest to the base. According to Ewald's theory, which is called the telephone theory, the basilar membrane of the inner ear vibrates throughout its structure at every sound. According to Bonnier's hydro-dynamic theory, the whole of the fluid of the cochlea is set in motion and comes into contact with the sensorial epithelium. The baresthetic theory of Marage attributes the perception of sound to variations of pressure in the endolymph.

Noises act by intensity, pitch, and tone. The most intense are the most injurious. The expressions often used are: "dull noise", "slight noise", "great noise" only give a vague description; but it is comparatively easy to determine experimentally the relative intensity of industrial noises which are regular and more or less continuous by comparing them with other noises of constant intensity. It is known that the sensitivity of the ear varies with the pitch of the sound (Helmholz, Zwaardemaker, Eschat, Vaquier). The normal sensitivity reaches from 256 double vibration (60') to 6,144 d. v. (60'). At higher and lower limits the sensitivity rapidly diminishes. Some experts consider the pitch to be the important element. At all events it is a fact that sounds of high pitch, shrill and very shrill, but not necessarily very loud, produce more lesions than the low deep or the high din in boiler-making works is more injurious than the roaring in cotton spinning mills; the reports of small calibre artillery and machine guns is more injurious than the booms of big guns (Cheatle). The pitch is more difficult to estimate than the intensity; but it may be estimated by comparison with sounds of a known pitch.

Tone in combination with pitch gives to certain noises the particularly disagreeable character which distinguishes them, such as the rasping and rattling sound of flints or the grating of saws or files. When the tone is one of such a painful nature it is very important, owing to the injurious influence it exerts on people of nervous temperament. Tone may easily be distinguished with considerable accuracy. It is tone which makes it possible to pick out different machines in motion without seeing them.

To these fundamental characteristics of noises must be added other harmful factors. First there is the time that the sounds last — the exposure to noises; the noises that last the longest are the most harmful, and in the noisy trades the workmen who suffer most are those who have been exposed to the noise for the longest time.

Rhythm is also an important factor in the harmful nature of an industrial noise. Noises that vary in intensity and are uncertain and irregular as to the moment of their occurrence are more harmful than constant, humming sounds to which one may learn to get accustomed. The suddenness with which some short loud noises burst out at longish intervals has a very disagreeable effect on the nervous system. Sounds, otherwise of the same variety, are much more important to the ear when they are sudden, intermittent, periodical, or more or less irregular.

Account must also be taken of resonance and the reflection of noise. Resonance may vary according to the position of the workmen in relation to the noise. Work within closed walls is more injurious than work in the open air. Thus hammering inside a boiler, the resonance of enclosed workshops where engines are built, or firing from warships or in enclosed rifle ranges are all very dangerous.

Apart from the resonance, it is necessary to ascertain whether vibrations are mingled with the actual noise. As a matter of fact, many factors contribute to the injuries caused by noises and vibration, and, what is more, they often act concurrently. All the trades in which workers are most exposed to lesions of the middle ear or of the nasopharynx, and constitute in themselves a risk to the integrity of the hearing, are more harmful if the noises are on an equality. Some experts, however, consider that such lesions of the middle
ear as suppurations and sclerosis, by preventing the passage of the deep-toned waves to the internal ear, act as a protection; thus Rodger and Got who, in speaking of the deafness that attacks artillermen, consider that those who have healthy ears suffer the most. Among other personal factors must be noted the part played by fatigue. Whereas noise may be tolerated, or even completely ignored, by those in good health, lowered physical or nervous health makes it impossible to bear up against the irritation and resulting fatigue caused by continuous loud noises. The age of the sufferer must be taken into consideration with the increase of lesions from arteriosclerosis. And this is said to occur chiefly in occupations which involve laborious physical work, such as men who carry heavy loads, blacksmiths, and stokers. The part played by intercurrent diseases, especially by syphilis, which intensify the sensibility of the central and auditory neurones, is important.

Among predisposing factors the effect of dust must also be mentioned; opening and carding rooms in flax spinning; locomotive mechanics; the effect of such poisonous substances as mercury carbon bisulphide, and especially lead; irritant poisonous substances as mercury carbon acid vapours, smoke, poisonous gases which show a predilection for the bony framework from which they are subjected being considered as excessive.

Obviously, in comparison to the effect of tremors when noise predominates, transmission through the frame assumes still greater importance when the vibrations and tremors constitute the chief factor. The hearing is then rapidly and seriously affected; the weighty body of the workman in contact with the vibrating ground, and particularly the bony framework from the feet to the head, constitute favourable conductors for the transmission of tremors (Peyser).

It is probable that in practice the two kinds of transmission play parts varying in importance with each particular case.

**PATHOLOGY**

Injuries due to noises and vibrations are of two kinds: (i) the effect on the ear, and (ii) the effect on the nervous system.

The symptomatology of auditory affections is considered elsewhere (see article "Occupational Diseases: Ear, Nose and Throat"). It is sufficient to say that they are due to a chronic degenerative neuritis of the cochlea (Peyser) and that they are serious in proportion to the length of time a workman has worked at a noisy occupation (Layet).

Nervous affections, the symptoms of which are also dealt with elsewhere (see article "Occupational Diseases: Nervous System"), are due essentially to functional disorders of the central nervous system, caused by mechanical lesions from noises and vibrations. Some sounds are fundamentally disagreeable and fatiguing; others, occurring frequently at irregular intervals,
with an unpleasant intensity, pitch and tone, require constant adjustment of the nervous system of the worker; this is wearing and leads to a waste of energy. The attention is distracted; hence arises necessity for concentration.

The effect of noises is not as well known as that of light, heat, or ventilation; all the more so as very few accurate facts are available on amelioration brought about by "anti-noise" apparatus, and that it is sometimes difficult to determine if it is the ear alone or the whole body which vibrates. It follows that the ill-effects caused by sound are not easily distinguished from nervous exhaustion resulting from direct vibration.

It is of value to bear in mind that, from the economical point of view, noise, even though of slight intensity, causes a marked diminution in capacity for work, and a diminution of output which may fall as low as to 40 per cent. of the normal, and an increase in labour turnover; whence follows a diminution of production.

**Propylaxis**

Propylactic measures would be greatly facilitated if the mechanism of hearing and the theory which corresponds most nearly to reality were exactly understood. However that may be, the measures that may be taken may be divided into two categories, measures applicable to the workman and measures applicable to work.

**Measures Applicable to the Workman**

First and foremost, proper means must be taken to protect the hearing. The best is still the ear tampon of compressed wool moistened or steeped in some greasy substance, such as vaseline, glycerine, or plasticine. It is necessary to remove such tampons from time to time to allow of ventilation and to let out the warm air from the ear. Numerous ear protectors (obturators plugs) have been made, but the metal kinds, which may break and allow fragments to penetrate into the interior of the ear, should be avoided. Protective helmets are only a last resource, for use in special circumstances where it is not possible to do without them. Men dislike wearing them, for they interfere with the usual methods of work or are uncomfortable on account of their weight or pressure; they prevent the clear reception of orders, and, by diminishing the perception of unusual noises or the warning shouts of comrades, constitute an extra cause of danger.

Another recommendation given to workmen is to open the mouth or to hold a cork (sic) between the teeth.

The protection of workmen is further assured by the use of substances which isolate the vibrations, by wearing boots with soft soles, and by using straw mats, felt braid, and special chairs with springs, like the one recommended by Gilbreth. But all these methods for eliminating vibrations vary according to particular cases. Thus, in hammering operations the use of benches with springs, for supporting the material which is being hammered, does much to reduce the vibrations experienced by the workman at each blow.

These prophylactic means must however be completed by the following measures:

(a) Medical examination on engagement, which enables a selection to be made and the elimination of workmen affected by diseases of the auditory apparatus, such as otosclerosis, lesions of the middle and internal ear, and insufficient patency of the tubes; or predisposed to these diseases by such lesions of adjoining parts as respiratory affections; or afflicted constitutionally with anaemia or neurasthenia; or of the adenoid type. In this way those particularly predisposed can be excluded from the most harmful workshops.

(b) Periodical medical inspection of workmen in noisy occupations. It might even be required to make this compulsory and give more particular attention to the detection of troubles at their beginning. Hence, the employment of workmen not used to noisy work; change of occupations; withdrawal from noisy occupations and the prohibition of the employment of workmen not used to noisy work. A useful measure consists in regulations for rest pauses. In some very noisy work it is recommended that the work be interrupted every fifteen to thirty minutes by a short interval.

(c) Medical treatment, making it possible to deal with affections at their very beginning.

(d) Measures relating to scientific organisation of work: changes of shifts in noisy work; change of occupations which is sometimes difficult to realise, or simply change of process in the same occupation; the prohibition of the employment of workmen not used to noisy work. A useful measure consists in regulations for rest pauses. In some very noisy work it is recommended that the work be interrupted every fifteen to thirty minutes by a short interval.
enable an effective fight to be put up against the aggravation of incurable deafness. The performance of some kinds of work in the open air is also a very important measure.

**Measures Applicable to Work**

These are the only rational efforts, for whereas the preceding ones aim at diminishing the harmful effect of noises, these aim at the suppression or diminution of noises and vibrations. They can only be arranged after careful examination of the surrounding conditions, and aim at protection against noises by isolating or deadening them. First of all, it is advisable only to allow noisy works to be set up in neighbourhoods where they will not be a nuisance, so that work can be carried on in the open air or with open windows. The same considerations should lead to the choice, for the situation of offices, of quiet streets or at the top of high buildings. Again, it would be advisable to prohibit noisy work in buildings of several floors.

Walls, ceilings and especially floors can be covered with anti-noise materials which diminish the production of vibrations from the ground. With this object, there may be used felts made of leather, hair, asbestos, or wood pulp, which can be made fireproof in some cases by silicate of soda or india-rubber, while, for the floors particularly, linoleum, or numerous special compounds now on the market, as "Acoustic", "Cellothex", or "Akoustolith" and special plasters are used.

Vibrations from machines may be deadened by arranging them on bases of special materials or on special foundations, independent of the floor used by the personnel, or enclosing them in special rooms closed by stout iron doors. The same considerations in offices and business premises lead to placing typists and other machine operators in separate rooms.

Careful control of businesses should permit: diminution in the number of noisy machines in each room, but chiefly elimination of noise and vibration, and of the causes which increase them, such as wear and tear of machines, lack of care and of repairs, clogging, improper use of unsuitable partitions, insufficiency of natural ventilation; in offices, the elimination of doors which grate or slam; the selection of machines and tools which are silent or provided with arrangements for reducing noises, such as silencers for internal-combustion engines; the substitution of pressure for impact, whenever that is possible; the elimination, properly so called, of harmful noises. It is necessary in this case to determine the origin of the noise, its intensity, its pitch and rhythm, and the local circumstances which increase the vibrations by which it is accompanied. The analysis of industrial noises can be carried out in various ways. Gradensigo in his well-known investigations used the following: tuning fork, Marbe's rings of lamp black, the phonograph, Edison's dictaphone, and the electric oscillograph. This last method, which is the most delicate and most complex, proved to him clearly that noises are made up of vibrations belonging to two and three and more groups, composed of numerous kinds irregular in periodicity and intensity.

It should be noted that noise is sometimes the best antidote to noise; that it is sometimes a good thing to place near machines making a moderate continuous noise, engines which periodically make a loud bang ing noise, as this breaks the monotony. In order to protect those in offices against neighbouring vibrations which are troublesome because it is impossible not to hear them, a recommendation has been made to adopt the plan of making an electric motor revolve fairly rapidly on a box of varying resonance, which reproduces variations agreeable to the ear, and interferes with the injurious vibrations, annulling their effects on the auditory centres.

The prevention of noises would be greatly helped if permissible noises could be standardised and if apparatus were used which enabled anyone to determine at once the strength of the noises observed. Some have been constructed, e.g. Low's audiometer which enables the noises to be measured.

Prophylactic measures should be further completed by propaganda and instruction of workmen on the dangers from noises.

In November 1927 a Commission was appointed in Germany to study, and conduct a campaign against, deafness due to noises in industry. A propaganda leaflet was also published by the Ministry of Labour in conjunction with the German Industrial Hygiene Society.

**Legislation**

Legislation can bring efficient help in the fight against noises, first of all by recognising officially noisy industries as dangerous trades, and then extending the benefits of compensation to industrial diseases caused by the noises. At the
present time Russia alone compensates deafness of industrial origin.

According to Peyser, the metal and textile industries, railways, and telephone services should be regarded as noisy trades.

The elimination of noises cannot but be profitable to all concerned: to the workers, because it improves their health and their enthusiasm, diminishes absences and lessens friction between employers and employed; and to the employers because it increases output and diminishes the cost of production.

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Occupational Diseases

Historical Review

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tique. — German: Gewerbeerkrankheiten: Geschichtse. — Italian: Malattie profes-
sionali (Storia delle). — Spanish: Enfer-
medades profesionales (Historia de las).

A brief summary of some few pages devoted to a historical review of occupa-
tional diseases in the civilised countries is not without interest. From the earliest
times it has been recognised that certain occupations constituted a more or less
serious risk for those engaged in them. Yet it has required the lapse of many years
— of centuries even — before the data assembled in regard thereto could be
systematically classified and studied by competent experts on the subject.

EGYPTIAN PERIOD

Very few details are known relative to the tragic conditions of workers in
ancient Egypt. The peasants — from whom taxes in kind and work could be
exact to the uttermost — were bound to the soil, which belonged to the Pha-
rahs. Their lot was so hard that when a famine occurred to aggravate
conditions the peasants revolted (2360 B.C.). Yet though thereafter the
peasants possessed the right to become hereditary tenants of the soil and
were free to cultivate it as they pleased, their conditions cannot have been
very happy if the evidence of the scribe who, in a long and well-known
address, warns young men against entering the occupation of agriculture
is to be believed (Papyrus Anastasi V).

The lot of the city workers has been thus crudely described as opposed to
that of the peasants:
I have never seen a blacksmith acting
as ambassador or a foundry worker sent
on a mission, but what I have seen is the
metal worker at his work: he is grilled
at the mouth of the furnace. The mason,
exposed to all weathers and all risks,
builds without clothing. His arms are
worn out with work, his food is mixed
up with dirt and rubbish; he bites his
nails, for he has no other food. The
barber breaks his arms to fill his stomach.
The weaver engaged in domestic work is
worse off in the house than the women:
doubled up with his knees drawn up to
his stomach, he cannot breathe. The laun-
dryman on the quays is the neighbour of
crocodiles. The dyeworker stinks of fish
spawn; his eyes are tired, his hand works
unceasingly and as he spends his time in
cutting up rags he has a horror of clothing.
(Papyrus Selier II.)

Stone and metal engravings, wall
paintings, all bear witness to the gangs
of forced labour dragging colossal
statues of kings and overlords. The
execution, moreover, of those gigantic
masterpieces of architecture which are
to-day the admiration of the world
gives some idea of the cruel sacrifices
demanded of the free citizens of the
Egyptian Empire.

When it is considered that the
temples and obelisks which defy the
passage of centuries were constructed
in a few months, that the blocks of
granite extracted from distant quarries
had to be dragged to the Nile moored
to immense rafts, that these obelisks
over 50 metres high and weighing
about 2,000 tons were sometimes
seven months only after extraction
(the time necessary for detach ing the
block from the quarry has been
estimated at two months, construction
of scaffolding one month, planing,
polishing and engraving the stone four
months), one may admire such "scientific management", but one can but
pity the countless slaves, criminals,
debtors, prisoners of war, workers
and peasants compelled to provide the
forced labour to which they were
subjected by brutal force in order to
complete these titanic constructions.

GREEK AND ROMAN PERIOD

Aristotle speaks of the diseases of
runners and prescribes a diet for
gladiators. Plato had already noted
that the artisan’s body is deformed by
the exercise of his profession. Pliny
refers to the dangers incurred in handling sulphur and zinc, and his *Natural History* speaks of masks made of transparent bladders used by the workers engaged in preparing vermillion in order to protect themselves against the metallic dust. Hippocrates (370 B.C.) was the first to recognise the toxic properties of lead, and reports a very serious attack of colic affecting a lead miner. He considered the most ordinary occupations as the true sources of disease. He was also the first to advise gymnastics, physical exercises, baths, massage and diet for the treatment of diseases and the maintenance of health.

Further allusions to occupational afflictions may be found in the writings of ancient authorities. Pliny, for instance, speaks of respiratory troubles, spitting of blood and hernia of runners. Martial refers to lesions of the eyes of sulphur workers, of callouses noticed as affecting horsemen. Juvenal reports eye lesions amongst forge workers and varicose veins amongst augurs which are ascribed to the standing position necessitated by the work of examining the entrails. Lucretius describes the tragic existence of the workers in mines and quarries: slaves worked in the Laurion mines (discovered in A.D. 483) for ten hours in galleries having a maximum height of 1 metre and a width of 60 to 90 cms., the air being stagnant and contaminated with smoke from the lamps; in the mines of Spain, Egypt 1 and of Syracuse

Pliny, Celsus and Galen refer to diseases peculiar to miners, tanners, fuller, bearers of burdens, chemists, etc. Galen has also described accurately the pathology of lead poisoning. Nicander (200 B.C.) established a connection between lead and pallor, stomach-ache and constipation noted amongst his patients. Avicenna mentions painter's colic, while Dioscorides and Aetius attribute this symptom to contact with litharge, and the latter also refers to wrestlers' diseases. Another doctor, Herodicus, held that workers should be advised to take sufficient nourishment.

1 It was in the valley of Ouady Maggharn about the year 5300 B.C. that the copper industry first arose, spreading later to the Sinai peninsula: women and children from the conquered countries and prisoners of war were the first — and during the whole duration of the Egyptian Empire the only — miners and workers engaged in them, being exposed to all imaginable suffering and goaded by the weapons of the soldiers.
(Lautumiae) they were exposed to the most serious diseases and the most atrociously trying work. He recalls the work of women and children at the entrance to the mines and outside the works. Lucien, in his Dream, also refers to deformities caused in men by trades and occupations. Ovid, Plutarch and others recall the sufferings of workers; but none proposed means of ameliorating them.

Much later (A.D. 643) an edict issued by Rotari made it compulsory for employers engaged in the construction or repairing of houses to compensate injuries to masons resulting from occupational accidents.

THE PREDECESSORS OF RAMAZZINI

In the Middle Ages there appeared already certain orders emitted by health officials in regard to certain industries, but these were intended rather for the protection of the inhabitants than for the workmen involved. In the fifteenth century a certain amount of interest in occupational diseases commenced to make its appearance.

Certain works on the diseases of men of letters are known, but mention should here be made of the pamphlet written by Ulrich Ellembog in 1743, to which Koelsch has just recently drawn attention (1927). This pamphlet on toxic fumes and vapours, Von den giftigen Besen Tempfen und Reuchen, was written as a sort of warning by the author, who had had the opportunity of noticing a certain number of occupational injuries amongst goldsmiths, especially poisoning, and who therefore judged it advisable to draw up a note as to the best means of their prevention. He insists on the toxic action of carbon monoxide (coal smoke) of lead, mercury and other metals, especially of their fumes, of aqua forte (nitric acid), antimony, etc., and he proposes numerous recommendations as to hygienic preventive measures. This note, which was first circulated in manuscript form, was only printed for the first time in 1524 (Koelsch). It is a remarkable fact that the pamphlet in question was not mentioned by medical

![Fig. 46. — Theophrastus of Hohenheim, known as "Paracelsus". (From an edn. of his works published in 1553.)](image-url)
writers of the time interested in industrial hygiene, but the reason is probably to be found in the fact that the publication remained unknown outside the circle of persons for whom it was originally intended.

It was, however, not until the sixteenth century that research on the subject is seen to have its rise. Paracelsus (1493-1541), a Swiss doctor and chemist, was the first to treat the subject in his book De Morbis Metallicis, where he publishes the results of observations made among Tyrolean miners. He investigates therein diseases of smelters and smelter workers due to inhalation of fumes and exhalations from the metals. Agricola published in 1556 a richly illustrated book entitled De Re Metallica.

In the seventeenth century Martin Pansa, a physician of Annaberg in Saxony, wrote on disorders incidental to miners and smelters (1614). Mathesis, Libavius and Ursinus were other writers who dealt with the subject about 1600-1650. Yet no really clear explanation of the nature and origin of the poisoning in its general form existed. Many and varied forms of illness were described and imputed by these authors in turn to lead, quicksilver, arsenic, cobalt and cadmium. Citois wrote on an epidemic of painters' colic or "Poitou colic" in 1639.

In 1656 Samuel Stockhausen, for twelve years doctor at Goslar in Brunswick, and entrusted by the Duke of Brunswick with the medical supervision and treatment of the metal workers in the Brunswick Luneburg mines, published a work based on his practical experience there and giving a lucid account of the so far very indubitably and vaguely characterised causes of disease. This work is entitled Huttenkatze or "Disorders caused by Smelter Fumes", with an appendix relating to asthmatic affections of metal workers. The book is written in Latin, but the appendix—dedicated to those mining officials who could not read Latin—is in German, showing the author's desire to render his treatise of practical utility. He made a close study of symptoms, made lengthy observations on the fumes and emanations from the different metals, and even underwent personal experiment in his efforts to determine accurately the causes of the disorders produced and earned the designation of "the miners' and foundry workers' friend" bestowed on him by a contemporary.

Loehniss again refers to the respiratory diseases of miners in 1690. Diemerbroeck, after carrying out post-mortem examinations of miners, states that in making a section of the lungs he had the impression of cutting a sandy mass.

In England the first documents dealing with the nature and results of occupation in dangerous processes are to be found in the Transactions of the Royal Society of England. They are of a theoretic and reflective character and touch on manufacturing and mining in Europe (white lead, silvering of mirrors by mercury, lead and coal mining). They appeared from 1665 onwards.

B. RAMAZZINI (1633-1714)

The seventeenth century provides some works relating to the diseases of courtiers, magistrates, men of letters, soldiers and seamen. Occupational diseases properly so called occupy but a very restricted space in clinical descriptions. Certain authors, however, describe isolated cases of mercury or lead poisoning in various occupations, but despite the growing interest being shown in certain branches of the subject of occupational disease about this time, it was not until 1700 that a comprehensive volume covering the whole field and at the same time embodying all past knowledge and vastly extending and completing it was published. This volume was the work of Bernardino Ramazzini, the father of industrial medicine, whom a modern authority has aptly described as "the benevolent and learned Italian physician of the seventeenth century, in touch with every available source of information of his own and preceding ages."

His Life and Work

Ramazzini was born at Carpi near Modena on 4 October 1633. He studied philosophy and medicine at Parma University, where he qualified in medicine on 21 February 1659 "cum signo laudis". After further medical study at Rome, he engaged in general practice in the provinces of Bologne, Canino and Marta, near Viterbo, and thereafter returned to Carpi, where he pursued classical and medical studies and practised as a doctor. In 1671 he went to Modena, and on the restoration of the University there, he was appointed Professor of Medicine, and was invited to pronounce the opening oration. He held two medical chairs there until 1688, when at his request one was assigned to a colleague. He worked in Modena for thirty years, eighteen of which were spent at the University, and it was while there that he prepared the greater part of the work which has made him so famous.
His fame as a student, professor, and writer spread throughout Italy and Europe, and many eminent foreign and Italian scientists visited him at Modena, and he was in correspondence with all the great scientists of his day. He gained distinctions from numerous learned societies. The Venetian Senate called him to the Chair of Practical Medicine at Padua; he accepted the call in 1700 and delivered an inaugural address before the University staff and an international audience on the progress of medicine in the seventeenth century as compared with the sixteenth century.

He won distinction at Padua as at Modena, and in 1706 was made a member of the Berlin Academy of Science and of the Academy of Science at Rome. His health suffered from the change to Padua; he developed arteriosclerosis in 1703 and gradually lost his sight. In 1710 he wished to resign, but he says his resignation was not accepted, and he continued to teach despite his sufferings till 1714, when he died of apoplexy on the way to the University. He is buried in Padua, in the church of St. Mary of the Armenians (now Saint Francis of Sales). His tomb bore no inscription — "sine titulo" — so that his exact resting-place is unknown. It is probable that it was displaced when the church was restored. A statue was erected to his memory at Carpi.

Besides his masterpiece, Ramazzini wrote on varied scientific subjects, showing singular scientific ability, and writing almost always in Latin. He was a literary man, a physicist, geologist, as well as a doctor and above all a hygienist, "Longe praestansus est praeses quam curare" being a maxim cited in his medical works. He was convinced of the necessity for the hygienist to extend his studies from the human organism to that of animals, despite the criticisms of his contemporaries, who found it indecorous for a doctor to study the maladies of animals. He engaged in important epidemiological and epizootic studies, the results of which were published in 1714, and his epidemiological research excels all previous work of this kind, his study containing observations useful even at the present time. He also studied the subsoil of Modena, and carried out research for determining the temperature of the subsoil and devoted himself to the study of meteorological conditions.

In his investigations into health and hygiene he covered not only craftsmen and manual workers, but also wrote on the diseases of intellectual workers ("De Litteratorum Morbis") and the health of nuns ("De virginitum sacrarum valetudini tuenda") and of princes ("De principum valetudini tuenda"). The latter work containing reflexions of moral and educative value as well as hygienic precepts. His claims to fame rest, however, not on these works, despite their merit, but on the "De Morbis Artificum Distriba" — "Disserantiones on the Diseases of Craftsmen", the first edition of which was published in 1700 and contained forty chapters. A second edition followed in 1713, to which the author added twelve chapters. In his preface Ramazzini says with justification that he has broken ground so far untouched by his predecessors, and that he has realised to the full the ultimate importance which the subject he unfolds was to assume in future. To the famous question "What is your occupation?", he was the first to realise the importance of the causative connection between occupation and disease, stating that the medical man, even when aware of his patient's profession, seldom attributes sufficient importance to it. He considered it to be the duty of medical science to engage in a specialised study of industrial conditions, in order that the worker might be permitted to gain his living without receiving bodily injury. Several critics and practitioners, "constitute a source of evil for those who follow them, and the unhappy workers, meeting with the worst of diseases where they have obtained sustenance for themselves and their families, die cursing their thankless calling."

Such were the ideas that led Ramazzini to devote his attention to occupational disease, and, having set himself the task, he was untingr in his efforts to accumulate data by means of study and observation. He wrote to well-known experts in various countries for information based on their experience, and he studied conditions at first hand in the homes and workshops of the craftsmen, which he characterised as "the only schools where any satisfactory knowledge of these matters can be obtained". He was even ridiculed for exposing his life to danger in the course of his investigations. His book deals with practically all trades and professions known in his day — metalliferous workers, gilders, chemists, glass-workers, potters, painters, dyers, tanners, bakers, millers, stonemasons, lead and silk workers, barbers, surgeons, nurses, porters, exponents, workers in the tobacco and salt industries, rag merchants, razor and lancet sharpeners, sailors, scholars, watch and trinket makers, soap-makers, and so on.

Ramazzini speaks of the "dismal calamities" inflicted on goldsmiths engaged in gliding silver and brass work by corrosive metal with mercury afterwards driven off by heat. Ramazzini's description of the pottery processes does not differ greatly from the conditions obtaining at present in this industry. He tells how the potters used to brown the clay by beating it with a piece of wood hung from the ceiling, and how the potters used to brown the clay by beating it with a piece of wood hung from the ceiling, but also wrote on the diseases of intellectual workers ("De Litteratorum Morbis") and the health of nuns ("De virginitum sacrarum valetudini tuenda") and of princes ("De principum valetudini tuenda"). The latter work containing reflexions of moral and educative value as well as hygienic precepts. His claims to fame rest, however, not on these works, despite their merit, but on the "De Morbis Artificum Distriba" — "Disserantiones on the Diseases of Craftsmen", the first edition of which was published in 1700 and contained forty chapters. A second edition followed in 1713, to which the author added twelve chapters. In his preface Ramazzini says with justification that he has broken ground so far untouched by his predecessors, and that he has
He distinguishes clearly between the different trades of the pottery trade, and the evil effects peculiar to each process; likewise, when dealing with the painter's trade, he seeks to isolate thenoxious effects produced by the various mineral colours, and he ascribes the melancholia frequently recorded as characteristic of the trade, when dealing with the processes in the pottery trade, and the evil effects peculiar to each process; like-workers in the early processes of this industry, for instance, making of catgut — and in imputing fever and illness to linewashed walls, and would probably have been greatly astonished at the present legisla-tive requirements in this direction. He notes with justice that the hatcheling of flax appears to he more unhealthy than the hatcheling of hemp. He makes an interesting reference, which strikes quite a modern note, to the additional fatigue suffered by bakers owing to their being obliged to work at night. He gives an accurate description of the unpleasant nature of the dust inhaled by silk spin-ners in the early processes of this industry — chiefly combing out of silk cakes, which retain part of the bodies of the silk worms mixed with them, and which, being dried in the sun, are drawn out by the workers into threads with small combs. Respiratory troubles experienced by these workers he attributes to the particles of the dead silk worms mixed up in them, and which, after being retained part of the bodies of the silk worms, mixed with them, and which after being put in the mouth repeatedly, cause considerable respiratory troubles, which are made worse by the presence of water and acid in the mouth, and which, if not removed quickly, are apt to cause the development of chronic diseases.

Ramazzini recognised that the principal causes of the numerous ailments which affect workers are twofold — the first and most extensive cause being the injurious qualities of the products handled, and the second the violent movements and unnatural postures demanded. He thus at that early date distinguished the two principal factors of ill-health as they are known and recognised to-day, saving, perhaps, the addition in the second case of excess of work and bad objective conditions.

Many of his precepts are so remarkably modern that they might well come under the designation of welfare recommendations to-day. For example he underscores the need for ventilation and unsuitable temperatures, and urges that workers in dusty trades should, in default of any known exhaust system, work in spacious rooms with their backs to the draught, and should wash their faces and rinse their mouths frequently with water and acid and quit work in such trades immediately they become threatened with lung trouble. He counsels rest intervals in work of pro-longed duration, and dwells much on the need for exercise and change of posture, being thoroughly convinced of the importance of faulty posture in producing ill-health in many trades. He observes that the excellent provision of baths for the people in Roman times had fallen into disuse, urging strongly the need for cleanliness and the institution of baths, massage, and regular exercise as essential to the maintenance of health and fitness.

He fully realised the importance of post-mortem examination as an aid to determining the cause of disease, and complains that owing to the ignorant superstition of his time he was often denied permission to proceed to an autopsy. His chief abilities were an exactness and accuracy of observation which enabled him, in spite of the lack of knowledge of anatomy, physiology, chemistry and bacteriology of his time, to arrive at surprisingly accurate conclusions.

It was not his intention, he stated, to offer a complete treatise on occupational diseases, nor to provide a long series of remedies for these, but merely to bring to the notice of practising physicians certain facts serving to guide them to a more successful treatment of those who toll.

Yet despite this modest assertion, his work, far exceeding the fulfilment of the practical aim referred to, has become the basis of the extensive literature which now exists on the subject of industrial hygiene.

**The Eighteenth Century**

Unfortunately, Ramazzini's work remained without practical import during this period, the political and social state of the various European countries preventing him from profiting by his instructions. His name fell into obscurity for about fifty years, for, according to Devoto, it was Adam Smith who in 1760 again drew attention to his treatise. However, the deleterious effects which attended the rapid expansion of industry caused the medical profession to turn to the study of Ramazzini. Twenty editions and many translations of his book appeared, of which we may cite: in England: translation by R. James (1745, 1746, 1750); in France: translation by Fourcroy (1711 and 1777); in Germany: *Opera Omnia* (Leipzig, published by Gleditsch, 1705 and 1718), and translation by Ackermann (published by Verlag Franzen and Grosse, 1780 and 1789), and Ilmenau (Verlag Voigt, 1829); in Italy, translations by Chiari (1745) and
The various authors who wrote on occupational diseases about this time, however, for the most part copied and paraphrased chapters of Ramazzini’s work. This is true of a volume published by Hecquet in 1740, of a Dictionary of Health which appeared in 1780 based on Hecquet’s work, of a Dictionary of Medicine published in 1772, and of a thesis on the Maladies of Craftsmen written by Dr. Skragge, of Upsala, in 1764, and to some extent also of Dr. Buchan’s references to workers’ diseases in his Domestic Medicine (1775), though the latter adds certain interesting original matter regarding a suitable diet for sailors, and the advisability of specially constructed tables for tailors and other sedentary workers, to correct faulty posture, and pleads for workers’ gardens and for greater facility for exercise.

In the course of the second half of the seventeenth century there appeared several works relative to occupational diseases and their treatment by the following authors: Isemann, Baker, Huxham, Zeller, Combaluzier, Tronchin, Gardane, Desbois de Rochefort and Poitevin.

Gardane’s book may be considered as the complement of Stockhausen’s. In 1740 Hecquet published Medicine, Surgery and Pharmaceutical Chemistry for the Poor. In 1775 Percival Pott was the first to study chimney sweeps’ cancer, and this subject received further development at the hands of Simmons, Aldis, Earle and Cooper. Robert Willan, an early dermatologist, dealt with bakers’, shoemakers’ and grocers’ itch and skin diseases of metal workers (1798). The Pocket Dictionary of Health (Paris, 1768) devotes several articles to occupational diseases; the Memoirs of the Academy of Medicine of France of 1779 contain remarks relative to accidents affecting workers handling tallow and animal hair.

In Italy J. P. Frank in 1779 called for measures of protection for women before and after childbirth, and expressed the desire to see women liberated from work for the three months preceding childbirth. Pietro Verri instituted in Milan in 1776 the “Societa Patriotica”, which inspired a movement in favour of agricultural workers suffering from pellagra. There was opened at Legnano in 1784-1787 a clinic for workers suffering from this disease. The same society interested itself likewise in tuberculosis affecting white lead workers, wool and silk workers, etc. The poet Parini suggested the creation of a Social Academy for Agriculture.

Scopoli had already studied injuries due to mercury and Mongiardini (1808) and Ravenna (1812) had described lesions of slate workers at Chiavari (Genoa). Towards 1870 there was founded at Manchester a Literary and Philosophical Society, which later counted amongst its members Percival Pott, Thackrah, Gaskell, and men like Owen, devoting their energies to the protection of women and children employed in factories and workshops.

In 1782 there was instituted in Germany, the “Annals of State Medicine” (Annalen für Staatsarzneikunde), which also constituted a valuable contribution to the subject.

THE NINETEENTH CENTURY

In the nineteenth century, with the rise of industrialism on the one hand and the concomitant development of biological and medical sciences on the other, the knowledge of occupational diseases achieved rapid development. The ravages made amongst the English working classes at the end of the eighteenth and beginning of the nineteenth centuries by the inauguration of the industrial system are well known and had for their consequence an enormous increase in disease. In 1761, according to Roscher, 50 per cent. of the English population died under the age of twenty. In certain industrial centres in 1833 the average age of the labouring classes was only twenty-two compared with forty-four amongst the upper classes, and later the death rate in the labouring districts reached 36 per thousand per annum as compared with 22 per thousand and for the country as a whole (Kober and Hayhurst). The dawn of the nineteenth century witnessed the first attempts at improving these appalling conditions. There commenced in Great Britain, and spread to the chief Continental countries, a gradual movement towards legislative regulation of industry — the limitation of number of hours worked, protection of women and children, and institution of factory inspectors. In 1844 there was legalised in Great Britain the appointment of regular “certifying surgeons” entrusted with the task of certifying the ages of children commencing factory work.

An increasing number of trades were brought within the scope of the
Factory Acts, and reports on conditions and causes of diseases in these trades were published. The report of the Medical Officer of the Privy Council in Great Britain for 1861-1862, for instance, contained such material, and dated from 1857 the removal of dust by mechanical means was first exacted by law in Great Britain, while 1805 marked the first demand for compulsory notification of certain industrial diseases in the same country, to mention but a few of the measures which marked legislative progress as regards prevention of industrial diseases at this time.

Though on account of her early industrial development Great Britain was the first country to institute factory laws, other countries later in adopting the enforcement of such laws were in a position to make more rapid progress. In addition to investigation and knowledge of industrial diseases, since they were able to profit by the English experience from the outset in establishing their inspection services and to have at their disposal scientific data in regard to medical, technical and chemical problems.

Concurrent with the growth of legislative measures dealing with the prevention of occupational diseases there occurred, concomitantly as the result of the revived interest being taken in the subject, a great expansion in the literature bearing on it and certain writers commenced to specialise in the study of these diseases.

C. Turner Thackrah. — In 1831 Charles Turner Thackrah published his book The Effects of Certain Trades and Habits of Living on Life and Longevity, based for the most part on his experience in the manufacturing district of Leeds, in which his practice was situated. As one might suppose, in view of the different periods in which they lived, there is an immense difference between the spirit in which Ramazzini and Thackrah dealt with the subject treated by them. Thackrah was a perfect anatomist and very conversant with methods of clinical diagnosis. His classification of the trades could hardly have been improved and the equity of his judgment alone prevented him from denouncing the employers for the deplorable industrial conditions which he describes (for instance, in the textile industry). He died of tuberculosis at the early age of thirty-seven. His premature death probably retarded by about half a century the progress of industrial medicine and surgery in Great Britain, as well as the improvement of industrial conditions. The second edition of his book appeared in 1839 (for further particulars see article by Legge in the Journal of Industrial Hygiene, 1920, No. 12, p. 593).

Thomas Bateman (1835), a pupil of Willan, pursued his master’s dermatological investigations still further.

European progress in public health was greatly stimulated by a report entitled The Sanitary Condition of the Labouring Population, published in England in 1838. An enquiry was effected in 1839 by J. Murray amongst rag sorters and rag merchants in Edinburgh. Allen studied conditions amongst petrol workers (kerosene) in 1861, and Leach those affecting cotton workers in 1864.

In France the movement likewise experienced wide development. In 1806 a dermatologist named J.J. Alibert published a report on the skin from the aspect of the exercise of various trades. In 1807 a prefect of police in Paris drew up a report addressed to the Minister of the Interior containing data relative to the tragic conditions of workers.

The year 1821 is a noteworthy date in the literature of industrial hygiene for it marked the foundation of the...
French periodical Les Annales d'Hygiène, which did more for the promotion of industrial hygiene in general than any other publication. Chevalier (1793-1879), a distinguished pharmacist and chemist, was an early contributor, and provided valuable contributions relative to the effects of lead, copper, chrome, arsenic, phosphorus, iodine, fuchsin and bromine, as well as to the skin disorders caused by these. Patissier re-edited Ramuzzini in 1822 and made some additions on the subject of skin diseases. He published for the first time mortality and morbidity statistics. In France exhaustive investigation was made into working conditions of wage earners by the "Académie des Sciences Morales et Politiques" in 1839, which gave an impetus to factory legislation. Tanquerel de Planches published (1839) an important book on lead workers' diseases. Villermé published in 1840 his work entitled L'Etat physique et moral des ouvriers, which also contains numerous occupational statistics relating to mortality and morbidity. Cadet Gassicourt expressed the idea of utilising these as the foundations of a rational system of vocational guidance. Thouvenin wrote on skin diseases in the woollen industry in 1846. In 1848 the "Académie des Sciences Morales et Politiques de France" instituted an enquiry into the physical, intellectual and moral condition of workers, with special reference to the effect of various occupations on the health and character of the working-class population.

Between 1825 and 1850 the Socialists (Fourier, Blanqui, and Prudhon) achieved effective action in regard to the study of occupational diseases. In the second half of the nineteenth century Halle de Arcet, Villerme and Parent-du-Chalet engaged in useful research relative to occupational dermatitis. Mahier and Chevalier in 1852 studied affections of the skin amongst mother-of-pearl workers. Desayre published in 1856 in the Annales d'Hygiène publique a long work on occupational diseases. In 1861 there appeared articles on antiline and nitrobenzol by Letheby, Oliviere and Bergeon. Maxime Vernois contributed in 1862 a striking article to the Annales d'Hygiène publique dealing with workers' hands, and about the same time research into diseases of workers handling skins was engaged in by Baugrand, Becourt and Chevalier studied the effect of bi-chromate of potassium on the skin, Chavret that of handling fuchsin, and Picard the skin diseases of spinners. Jorden wrote in 1863 on steel workers' diseases, and Delpech in the same year treated diseases of workers in the rubber industry with reference to carbon bisulphide poisoning. Thelimer wrote in 1864 on skin affections of laboratory workers. Giraudon, Gibeau, Maout-Gervais and Devergie published monographs on skin diseases, whilst Bazin was the author of Lecons théoriques et chimiques sur les affections cutanées artificielles, dealing with many categories of industrial workers. Delpech published in 1869 and 1876, in collaboration with Hilairet, the result of investigations into diseases of chrome workers, whilst the latter year also witnessed the appearance of Dr. Layet's Hygiène des Professions et Industries. An important contribution by Napier to the Manuel d'Hygiène industrielle dates from 1882 and that of Poincaré from 1886.

In German-speaking countries contributions to the literature at the beginning of the nineteenth century were much less numerous. Nevertheless, the Viennese School of Dermatology was founded in 1840 by Hebrau, and his pupils Kaposi and Neumann engaged in fruitful research. Cless, in 1842, wrote on bakers' diseases. In 1847 E. von Bibra and L. Geist published a study on the diseases of match makers and in particular on phosphorus neureisis. Breilisle studied the skin diseases of workers manipulating human and animal hair (anthrax) and advocated sterilisation of the hair. Halfort in 1845 published his Entstehung, Verlauf und Behandlung der Krankheiten der Künstler und Gewerbetreibenden, devoted to pathology and prophylaxis, and dealing with toxic gases, dusts, injurious effects of faulty posture, fatigue and abnormal temperatures. Schirmer (1856) dealt with lignite workers, Hoeisbeck (1858) with printers, and Keller with mirror workers.

The town of Hanover and, in Denmark, the town of Copenhagen, provided (1861) some striking statistical data relative to skin affections amongst bakers. In 1861 Kussmaul published a monograph on constitutional mercurialism.

In 1865 Eulenberg published Die Lehre von den Schädlichen und giftigen Gasen. Kuntz, in 1868, published the result of a study of diseases affecting workers in the sugar industry. In the same year Dankwerth wrote on petroleum eczema and Hoppe on the maladies of barbers and tobacco workers. The Industrial Code of the North German Union laid down that "every manufacturer must, at his own cost, establish and maintain all necessary
appliances for safeguarding his employees against dangers to health and life". These measures were extended to form the Code of 1891 and became the basis of the present factory legislation in Germany. In Germany the Factory Acts are general in character and local authorities have power to interpret them as circumstances demand. In 1870 Hirt published an extensive treatise on occupational diseases entitled Die Krankheiten der Arbeiter, which was reprinted in 1882, and in 1876 Eulenberg published a work entitled Handbuch der Gewerbehygiene. Ordtmann in 1877 drew attention to smallpox occurring amongst rug sorters, and Max Pettenkofer, the founder of experimental hygiene and editor of the Handbuch der Hygiene, induced Max Gruber, 1881, and Ogata, 1882, to undertake, with the aid of respiration apparatus, investigations on the action of sulphuric acid and carbon monoxide. In 1882 Popper published in Stuttgart his Lehrbuch der Arbeiterkrankheiten und Gewerbehygiene.

Since 1884 quantitative studies of upwards of thirty-five gases based on animal experiments and observation in industry, where possible with human control experiments, have been carried out by K. L. Lehmann of Wurzburg, assisted by his pupils.

Albrecht in 1896 published his Handbuch der praktischen Gewerbehygiene, and in 1898 Sommerfeld published the first volume of his Handbuch der Gewerbekrankheiten. In 1897 there appeared an important volume on industrial hygiene edited by Weyl, forming the eighth volume of a large treatise on health, and two years later R. Laudenheimer published a study on carbon bisulphide poisoning amongst workers in the rubber industry. In 1906 there appeared an important work Handbuch der Arbeiterkrankheiten edited by German authorities under the direction of Weyl.

In Italy the movement developed in similar fashion. Puccinotti (1837) drew attention to the tragic lot of workers occupied in foreign factories. Later there appeared collaborative publications dealing with occupational pathology and hygiene, amongst which may be mentioned those of Boeri, Contini (1881), Mantigazza (1881), Sanarelli and Trambusti (1895), Revelli (1898), not to mention numerous articles disseminated throughout the technical press.

In the United States, as elsewhere, the rise of machine production was accompanied by exploitation of child labour and enormous wastage of human effort and human life. Attention was first bestowed on the gravity of the social problems arising therefrom about 1856, and thereafter investigation committees were appointed and legislation introduced. The growth of factory legislation was fairly rapid from 1850 onwards, but prior to 1877 no legislation in regard to factory inspection existed in the United States.

The first American contributions to the literature on industrial hygiene date approximately from the prize dissertation published in response to an appeal by the New York Medical Society in 1837 entitled On the Influence of Trades, Professions and Occupations. In 1869 Walker published a monograph entitled Occupation of the People, and from 1880 to 1890 twenty-two American contributions were made to the literature. From 1890 onwards there has been a great increase in the number of contributions made to this subject.

In Australia an enquiry was instituted in New South Wales in 1893 into the incidence of lead poisoning amongst miners in the Broken Hill mines.

THE TWENTIETH CENTURY

As regards progress effected since 1900, it is preferable to consider separa-
ately the advance made in each of the leading industrial countries, as everywhere a great impetus was given owing to the increasingly scientific character of the methods pursued. Germany and Great Britain stand first amongst the European countries as regards regulation of unhealthy trades. Progress along the lines of drafting special rules affecting whole classes of workers is becoming more general. The statistical data provided by the German Accident and Sickness Assurance Associations have proved of great value in furthering investigation and research. In the United States large-scale investigations into special diseases, aided by statistical investigation, have contributed greatly to progress.

The European Contribution to Industrial Medicine

The profound significance of industrial health and the urgent necessity for adequately protecting the health and safety of the workers were forced on the public attention during the war of 1914-1918 by the scarcity of labour. Thus, for example, in Great Britain there resulted the appointment of the Health of Munition Workers Committee, the work of which has since been supplemented by Home Office investigations into industrial fatigue (Industrial Fatigue Research Board). As the result of the findings of this Committee an Act was passed in 1916 to secure the welfare of workers in factories and workshops, thus opening up a new phase in activity for the promotion of industrial hygiene. This tendency to promote industrial welfare in some measure actuated by efforts to abolish industrial unrest and secure contentment is in strong contrast to the position in the United States, where progress during the same period has rather been along strictly medical lines, having for its fundamental object diseases prevention.

In 1902 a very important work, prepared by medical experts under the editorship of Sir Thomas Oliver, was published under the title of Dangerous Trades, and in 1908 Sir Thomas Oliver published the first edition of his Diseases of Occupation, revised in 1916. In this year also there appeared a second edition of Weyl's Treaty of Industrial Hygiene. In 1909 there was published a Treatise on Occupational Diseases and Accidents by Greer.

Credit is due to Sir Thomas Legge for having, with the aid of factory inspectors and certifying surgeons, made very important contributions to a great number of problems on industrial medicine. In 1912 he published, in collaboration with Sir Kenneth Goadby, an important study entitled Lead Poisoning and Lead Absorption. He also made valuable contributions to Kober and Hanson's Diseases of Occupation and Vocational Hygiene and translated into English Rambousek's book Industrial Poisoning from Fumes, Gases and Poisons in Manufacturing Processes.

Leonard E. Hill investigated compressed-air illness in 1912 as well as the general evils of bad atmospheric conditions, and made highly important contributions to the science of ventilation and lighting of workshops, as well as the relation of food values to occupation. Haldane has done notable work in the study of atmospheric conditions and dust inhalation and also in regard to miners' health and compressed-air work. The studies made by him are very remarkable and represent one of the most valuable contributions made on the subject. Dr. Collis has gained distinction by his studies on physiological and pathological effects in regard to the action of dust in the production of lung disease (1910), in regard to housing in its relation to factory life, as a factor in tuberculosis causation (1914) and by studies on industrial pneumoconiosis (Milroy lectures, 1915), occupational injuries (1915) and welfare work in factories (1919). Research into occupational cancer mortality has been carried out by Green- wood, who has also devoted himself to the consideration of industrial accidents, fatigue and welfare work, etc. In 1921 Collis and Greenwood published The Health of the Industrial Worker, giving a satisfactory account from the standpoint of industrial hygiene of the profound changes in civilised life in the past century and as a result of the rising development of modern industry. In 1923 Hope, Hanna and Stalybrass published an excellent work entitled Industrial Hygiene and Medicine.

In France mention should be made of the studies effected by the Ministry of Industry and Commerce, one in 1901, Poissons industriels, and the other in 1908, Maladies professionnelles, in the preparation of which various experts participated (Leroy des Burres, Courtois de Ruffit, Brémond, Heintz, Dufraisse, J. Josias, Thoinot). Thoinot, in collaboration with Brouardel, made repeated contributions to the study of occupational diseases on the occasion of seeking a solution of problems in forensic medicine raised in regard to
industrial poisoning. In 1908 there appeared an important treatise on industrial hygiene, the result of joint collaboration on the part of Leclerc de Pulligny and Boulin, the second edition of which was issued in 1927. There should likewise be mentioned the works of Breton on lead poisoning due to white lead and on occupational diseases, Brouardel and Gilbert (1912) on industrial poisoning, Hém de Balzac and Hébert (1912) on various problems of industrial hygiene, Bargeron (1919) on hygienic construction of factories, Agasse-Lafont, Martin (Lyons), etc. There should not be omitted mention of the works of Freres and Langlois, who dealt with numerous aspects of hygiene and industrial physiology. The movement in favour of the study of occupational diseases has greatly developed since the war, and mention should be made of the foundation in 1925 of an association called the "Société d'hygiène publique, industrielle et sociale" (Society of Public, Industrial and Social Hygiene) which devotes a part of its activity to the study of problems of industrial pathology, likewise the Paris Institute of Industrial Hygiene and the creation of an Institute for Occupational Diseases attached to the Faculty of Medicine in Lyons University, together with the foundation in 1929 of a periodical entitled La Médecine du Travail (Industrial Medicine), edited by Professor E. Martin.

In Belgium the movement received a new impetus in 1895 thanks to D. Gilbert, who has since then been Chief Medical Factory Inspector in that country. This service, as well as the numerous factory surgeons throughout the country, constantly render valuable service in the various spheres of industrial hygiene and pathology. Even a brief survey of the work undertaken in Belgium would not be complete without reference to the works of Malvoz (Liège) and of Herman (Mons), particularly in regard to the campaign against ankylostomiasis.

Several general studies on occupa-

![Fig. 49. — Clinic for Occupational Diseases of Milan. (Its construction was decided on by the Municipal Council on 20 November 1902. It was opened on 20 March 1910.)](image)
and in addition of several other experts, contributes regularly to progress in the field of industrial medicine. The treatise on "Occupational Diseases" by Heijermans appeared in 1908 and a new edition was issued in 1928 in two volumes. The Society for Medicine and Surgery of Occupational Diseases and Accidents publishes a monthly review. A service for occupational selection and industrial pathology attached to the Faculty of Medicine has just been created by the University Council in Brussels.

In Germany a monumental volume on occupational diseases, the work of a number of recognised experts under the direction of Weyl, was published in 1908. In 1914, 1917 and 1921 there appeared the second edition of Weyl's treatise, published by Gärtsch. Dr. Lehmann's treatise Lehrbuch der Arbeits- und Gewerbekygiene appeared in 1919 and is remarkable for the precision of its data based on the vast personal experience of the author. He has studied the toxic effects of a great number of metal fumes by dosing animals and has determined the channels and extent of absorption of poisons; he has formulated new scientific theories relative to the toxicity of many industrial poisons, chiefly those of an organic nature.

Interesting work has been effected by the Federal Health Office represented by such experts as Wolffhugel, Renk, Wutzdorf, Rost, Engel and a certain number of factory inspectors: Joelsch, Muller, Bochfeld, Curschmann, etc., as well as many other doctors in industry (Müller, Bochfeld, Curschmann), etc. Mention should likewise be made of the extensive treatise on social hygiene (1926-1928), the work of Schlossmann, Gottstein and Teleky, one volume of which is devoted to occupational hygiene; the treatise of Syrup (Handbuch des Arbeiterschutzes und der Betriebssicherheit, 1927) and the work of Sommerfeld (Atlas der Gewerblichen Gesundheitspflege, 1926).

Special courses of occupational diseases are held in ore- than in Germany universities. Apart from the numerous publications devoted to the subject, much propaganda work is done by the Association for Industrial Hygiene (Frankfort-on-Main).

Austria has not failed to furnish a contribution to the subject in question. It suffices to recall the work of Ramhosek (1908), besides the publications of Brezina, Sternberg and H. von Schroetter.

In Czechoslovakia, Loewy published his treatise in 1924. Mention should also be made of the important institution designated under the title of "Masarykova Akademie Prace", one section of which deals with industrial physiology and psychotechnics. In 1928 there was instituted an association dealing with questions of social medicine and hygiene. A chair of industrial medicine was instituted in 1929.

For Hungary reference should be made to the research effected in regard to lead poisoning, especially in the pottery industry by Chyzer, as well as to the works of Friedrich, etc.

In Greece Catsaras, as the result of detailed research, has proposed new methods of decompression for divers, and Savas has furnished contributions in the field of industrial medicine.

In Poland many experts have devoted their time to industrial medicine. Amongst others may be mentioned the names of Zielinski, Karaffa-Korbut, etc. A periodical entitled Higijena Pracy devoted to industrial hygiene has been published since May 1928.

In Portugal there appeared in 1924 a treatise on industrial hygiene edited by Corbo d'Andrade, who published also in 1927 the Quesitos de Higienie Social.

In Switzerland the works of Schuler, O. Roth, Zangger and Vogt, etc., are well known to experts.

In Italy progress has likewise been made in regard to industrial hygiene. Amongst the general and special works on the subject, there should be cited those of Giglioli (1902), Pieraccini (1906), Allevi (1907), Anna (1909), Loriga (1910), Carozzi (1914), Ranelletti (1923), Ferraruzini (1929). The very important contributions to the subject made by institutes directed by Devoto, A. Monti, C. Biondi, L. Ferramenni and their collaborators are also well known, the movement having begun at Pavia at the instigation of L. Devoto.

The first industrial clinic was founded in Italy in 1910 by the town of Milan. It comprises consulting rooms, wards for patients affected with industrial diseases, laboratories, library, museum, courses of medical instruction, propaganda, publications and enquiries, etc. It constitutes a highly important centre of industrial hygiene and pathology. A second industrial clinic was founded in Naples in 1919 and new chairs of industrial medicine have been created at Turin (1929), Parma (1930), etc. Polyclinics for workers have been organised at Rome, Genoa, Turin, etc.

In Italy the movement found expression likewise in the organisation of periodical national congresses devoted
to industrial diseases (Palermo, 1907; Florence, 1909; Turin, 1911; Rome, 1913; Florence, 1922; Venice, 1924; Parma, 1927; Naples, 1929), congresses in which technical experts and scientists have actively participated. Special medical reviews devoted to the subject also exist: Il Ramazzini (1907-1915), Il Lavoro, now entitled La Medicina del Lavoro, founded by Devoto in 1901.

In Spain, the Barcelona local authorities in 1929 created a chair of industrial medicine and intend to organise a clinic for industrial diseases and accidents. A course of industrial medicine is given at the Institute for Occupational Rehabilitation at Madrid, which also publishes the periodicals Medicina del Trabajo y Higiene Industrial.

In Russia pre-war research was chiefly connected with the petrol industry (Berthenson), but since then Russian scientists and technical experts have become increasingly interested in questions of industrial hygiene and pathology. There should be cited the works of Kaploun, Lachtenkoff, Kagan, Vigdortschik and Wassilewsky devoted to occupational health. Numerous institutions for the study of occupational diseases have been founded, notably at Leningrad, Kharkov and Moscow. There should likewise be mentioned a periodical review devoted to industrial hygiene.

The American Contribution to Industrial Medicine

In the United States the number of publications relative to industrial hygiene has greatly increased, especially during the last few years.

The National Committee on Child Labour was incorporated in 1906, and resulted in the formation of the Children's Bureau in 1911. This organisation, amongst other aims, seeks to promote child welfare and to investigate dangerous occupations with a view to exclusion of children from these. In 1884 a Bureau of Labour was set up in the Department of the Interior, and in 1915 a Division of Industrial Hygiene and Sanitation was created with an Office of Field Investigation into Occupational Diseases. The Public Health Service and the Service of Mines have done excellent work in the sphere of scientific investigation into a number of dangerous occupations and processes. The first publication, issued in 1914, dealt with trachoma amongst steel workers, and was followed by articles on a wide range of subjects. Recently much good work has been done under Professor Winslow in regard to the study of factory ventilation and industrial dust hazards. The post-war programme covers:

1. continuing and extending health service in industry with a view to precise determination of the health hazards and of the best means for preventing them;
2. securing adequate reports of disease prevalence in industry and of sanitary conditions in industrial establishments and communities;
3. national development of adequate systems of medical and surgical supervision of employees in places of employment;
4. establishment, in co-operation with the Department of Labour, of minimum standards of industrial hygiene and prevention of occupational diseases; and
5. improvement of sanitation in industrial communities.

In 1910 and 1912 conferences on industrial diseases were held at the instigation of the American Medical Association for Labour Legislation. In 1915 a Section of Industrial Hygiene was organised in the American Public Health Association.

As regards training in industrial hygiene, most medical schools and colleges have courses in hygiene and public health, a certain number of lectures being generally devoted to industrial hygiene and dangerous occupations.

Much useful research has been done in the various medical schools throughout the country, into such subjects as: packers' itch, health hazards of the pearl button industry, strength tests in industry, TNT poisoning, hours of work as related to output and the health of the workers.

Harvard Medical School was the first in the world to confer a degree in industrial hygiene (session of 1918-1919), and its staff has made many contributions to the subject. It is also responsible for the publication of the Journal of Industrial Hygiene. Several States possess a Division of Industrial Hygiene. That of Ohio provides courses in industrial medicine and surgery. The first clinic for occupational diseases was opened at New York in 1910. Others have been instituted in Chicago (1911), Boston (1910), etc. A great deal of research has been done in these clinics, comprising enquiries into such subjects as: compressed air illness, brass poisoning, lead poisoning, pulmonary diseases of potters and cement workers, etc.

The Bureau of Statistics of the Department of Labour has published, in the series entitled "Industrial Accidents and Industrial Hygiene", some highly interesting reports, amongst which should be mentioned: Lead Poisoning in Potteries, Tile Works, and Porcelain Enamelled Sanitary Ware Factories; Danger in Use of Lead in Painting of Buildings (report of British Departmental Committee); Lead
Poisoning in the Manufacture of Storage Batteries; Lead Poisoning in the Smelting and Reclamation of Lead; Deaths from Lead Poisoning; Hygiene of the Painter's Trade; Dangers to Workers from Dust and Fumes, and Methods of Protection; Industrial Poisons Used in the Rubber Industry; Industrial Poisons Used or Produced in the Manufacture of Explosives; Industrial Poisoning in Making Coal-Tar Dyes and Dye Intermediates; Effect of the Air Hammer on the Hands of Stone-Cutters; Anthrax; Carbon Monoxide Poisoning; The Problem of Dust Phthisis in the Granite Stone Industry; Phosphorus Necrosis in the Manufacture of Fireworks and in the Preparation of Phosphorus; Hygiene of Printing Trades; Health Survey of the Printing Trades, 1922-1925; Mortality from Respiratory Diseases in the Dusty Trades; Causes of Death by Occupation; etc.

In June 1910 the first National Conference on Industrial Diseases (held at Chicago) was called by the American Association for Labour Legislation. The President, in his opening address, stated: "This is a warfare in which science, labour, business enterprise, and Government must all unite." A Committee of Enquiry appointed by the Conference estimated the economic loss to the country through sickness due to preventable causes to amount to $350,000,000. An informal Committee of Industrial Hygiene Experts formed in 1910 was in 1914 absorbed by the American Association for Labour Legislation. Much valuable work has been effected by special commissions and by official and private investigations in relation to the study and prevention of occupational disease. Mention may here be made of that of Illinois in 1911, of Ohio (Hayhurst) in 1915, etc.

In 1911 a series of annual Safety Congresses. In October 1912, Lew R. Palmer suggested the creation of a permanent association to be designated the National Council for Industrial Safety; it was instituted in 1913, with a section on hygiene. A Committee appointed by this organisation is now investigating the prevention and control of occupational skin diseases.

Section 4 of the Fifteenth Congress on Hygiene and Demography, held at Washington in 1913, was devoted to occupational hygiene, and stimulated a profound interest in the subject. The sixty-four contributions by distinguished experts served to lay the foundations for a scientific literature on industrial medicine in America, and in the following years many useful volumes on the subject were published.

In 1917 a conference was called at Washington by Mr. Gompers, of the American Federation of Labour, to discuss recommendations for promoting health and efficiency amongst industrial workers. For this conference reports were prepared on such subjects as: industrial fighting, dust hazards and general welfare. In 1917 the Council on National Defence organised a sub-section on industrial medicine: 1919 saw the inauguration of the Journal of Industrial Hygiene and The Nation's Health, two excellent periodicals devoted to industrial hygiene, medicine and surgery. The American Public Health Association participated in the proceedings of the Washington Conference.

The American Medical Association of Industrial Physicians and Surgeons was formed in 1916 with the object of stimulating scientific study and research in industrial medicine, advancing the adoption of health services in industry, and raising the standard of physicians in industrial practice. Much good work in pursuit of these aims already stands to its credit. In the State of New York there exist the Workers' Health Bureau and the New York State Society of Industrial Medicine, the official organ of which is The Industrial Doctor.

In 1925 Alice Hamilton published an interesting volume entitled Industrial Poisons in the United States. J. C. Aub, L.T. Fairhall, A.S. Minot and P. Reznikoff in 1926 published an important study on lead poisoning, and finally in 1927 Yandell Henderson and H. W. Haggard issued a publication dealing with toxic gases.

Though it is hardly over twenty-five years since serious attention was first bestowed on problems of industrial hygiene in America, good progress has been effected and has borne fruit, as proved by reduced mortality rates in certain trades. Dr. Fiske, in his striking report (1923) on the problem of the economic loss and waste in industry, to be attributed to lowered health conditions, sickness and accidents, reckons 42 per cent. of such illness to be preventable, and is led to expect from adequately applied preventive measures a life extension for workers of fifteen years. Since 1900 a probable extension of five years has, he states, been achieved, and the former estimated loss per worker of thirteen working days per annum may, he considers, be now computed approximately at seven days.

In Brazil a treatise on forensic medicine relative to industrial accidents and occupational diseases was published in 1926, the work of Afranio Peixoto, Flaminio Favero, and Leonidio Ribeiro, of the Medical Faculties of Rio de Janeiro and Sao Paolo.

In Canada there is an Industrial Clinic under the direction of Pedley.

Other Countries

In South Africa gold and diamond mining has attracted the attention of experts on industrial hygiene by reason of the different health problems involved. Very important organisations, such as the South African Institute for Medical Research and the Miners Phthisis Bureau, etc., as well as a
number of scientists (Mavrogordato, Orenstein, Ireland, Irvine, Watkins-Pitchford, etc.) have studied questions relating to detection, diagnosis, clinical and radiological work and the prevention of silicosis.

In Japan a very important movement is in progress, in which experts in the various fields of industrial pathology have participated. An Institute for Industrial Research, situated at Kurasaki, is directed by Teruoka (see fig. 50). This institute was founded in 1921, thanks to the generosity of Mr. Magosaburō Oohara, President of the Kurasaki Cotton Mill Company. Its aim is to study human industry from the medical and psychological point of view.

It suffices to recall, in fact, the enquiry instituted in regard to the occupational risks to which workers were exposed in the construction of the Sydney Tunnel (1902), that conducted in regard to the incidence of pneumoconiosis and pulmonary tuberculosis in mines (1904), the investigations at Bendigo (Victoria, 1906) and the enquiry into the incidence of pneumoconiosis and lead poisoning amongst workers in the Broken Hill mines (1914), etc. In 1921 the American authority Lanza, in collaboration with Robertson, organised a Central Office of Preventive Medicine, and in 1921 also there was created a Division of Industrial Hygiene under the direction of Dr. Robertson, who, on

Fig. 50. — The Oohara Institute for Industrial Science at Kurasaki (Bitchu, Japan).

taking into consideration other social problems. The institute comprises five sections: industrial physiology, industrial psychology, biometry, nutrition, social hygiene. The results of the activities of the institute are published in a quarterly periodical (in Japanese) as well as in a Japanese handbook on social hygiene, which appears also in other languages.

Since its inauguration in 1901, the Commonwealth Government in Australia has never lost sight of problems of industrial hygiene and pathology. His decease, was succeeded by Dr. Keith Moore. The first official general conference, the aim of which was to discuss and to propose to the Government measures of occupational and social hygiene for workers, was held in 1922, a second in 1924, and a third in 1927. The very important decisions adopted are to be found in the reports published by the Division of Industrial Hygiene, which has also issued a whole series of reports containing the results of very interesting enquiries. There should also be mentioned act-
ivities in the same sphere engaged in by the Hygiene Departments of New South Wales and Victoria, etc. A Royal Commission on Health, set up in 1906, also dealt with industrial hygiene and pathology, and suggested a whole series of practical measures for adoption. There should finally be recalled the scientific contributions of Badham, of New South Wales, Armit, of Sydney, Chapman, Smith and Walter Summons, who have published striking contributions to the problem of tuberculosis amongst the Bendigo miners, with special insistence on the anti-dust campaign, and on the need for adequate ventilation in mines.

MUSEUMS OF INDUSTRIAL HYGIENE

Several cities and towns possess Industrial Safety and Hygiene Museums which show by means of plans and photographs, methods of occupational disease and accident prevention, arrange for lectures, and publish pamphlets and propaganda tracts. There may be mentioned in this connection the industrial museums or exhibitions of industrial hygiene and safety in Amsterdam (opened in 1883), Milan (1894), Munich (1900), Berlin-Charlottenburg (1903), New York (1907), Budapest (1908), Vienna (1909), Lausanne and Turin (1911), and London (1927), the latter organised by the Home Office. Special collections dealing with particular problems (hygiene, miners' safety, for instance) have been organised at Mons, Gelsenkirchen, etc., and a collection forms part of the important Hygiene Museum in Dresden.

NATIONAL AND INTERNATIONAL PROTECTION OF WORKERS

The practical knowledge of occupational diseases in the various countries is aided by the organisation of medical inspection in industry, compulsory notification of occupational diseases and their compensation. These legislative measures, by providing scientific data, contribute to the improvement of knowledge of occupational pathology. The data thus collected are valuable not only to the countries possessing such schemes, but also to other countries.

The question of international protection of workers was raised for the first time in 1887, at the Congress of the International Association for Labour Legislation, which demanded protection of workers in unhealthy trades. The first International Conference, however, was not held till 1890, in Berlin. In 1896 the International Conference called by the Parisian trade unions in Paris raised the question of the principle of compulsory protection: provision in the workrooms of apparatus for protecting the health of workers, prohibition of certain processes and of the use of certain raw materials particularly harmful to the health of workers. In 1897 there was held in Zurich the International Congress for the Protection of Workers.

The International Association for Labour Legislation (Basle) was founded after the International Congress of Paris in 1906. The enjoyment of occupational diseases and accidents has been one of the various aims pursued by means of publications in French, English and German of studies on certain questions, and on the occasion of its biennial meetings it has engaged in the study of numerous problems of occupational hygiene. Prizes have been offered for the solution of problems of industrial hygiene. Thanks to the activities of this international organisation, it was made possible for authorities on the subject to draw up a list of this industrial poisons.

Action on an international scale has likewise expressed itself in the organisation of international congresses on occupational diseases (Milan, 1906; Brussels, 1910; Vienna, 1914; Lyons, 1929; Geneva, 1931).

It is advisable to recall to mind the fact that there was founded as the outcome of the Milan Congress in 1906 the Permanent International Committee for the Study of Industrial Medicine. Composed of distinguished experts from all countries, it has dealt with questions of industrial pathology, and has organised international congresses, etc. Its activity was suspended during the war, but as soon as the conditions were again favourable its members reconstituted, and resumed organisation of congresses in the form of meetings, the first post-war congress being that held at Lyons in 1929.

The international activity of the International Association for Labour Legislation, which had its headquarters in Basle, is at present carried on by the International Labour Office by means of its Hygiene Service and its Advisory Committee on Industrial Hygiene, which numbers amongst its members distinguished experts from many countries (see publications of the International Labour Office).

At present there is a widespread movement in favour of creation in the universities of laboratories for the development of research into industrial hygiene for doctors and factory inspectors, as well as the creation of private organisations with the same object.

Gradually the nations are coming to realise the truth underlying the words of Ramazzini: "It is but a poor profit which is achieved by the destruction of health."

BIBLIOGRAPHY

Cf. the quarterly publication of the INTERNATIONAL LABOUR OFFICE: Bibliography of Industrial Hygiene, No. 12, Dec. 1925, pp. 33-40, and No. 8, June 1929, in which are given a list of works relative to industrial hygiene and pathology.
Definition and Compensation


At the Seventh Session of the International Labour Conference (Geneva, 1925) the question of compensation for occupational diseases figured on the agenda. On this occasion the International Labour Office placed before the Conference a document comprising data relative to compensation in those countries which had issued measures dealing with this type of insurance. Since 1925 legislation in regard thereto has developed rapidly, and its beneficial effects have extended increasingly, with the result that at the present time the task of resuming the problem of compensation at its present state of progress cannot be dealt with within the bounds of a single article. For this reason the Office intends to revise and bring up to date a new edition (1931) of the study undertaken in 1925.

In the present article attention will therefore be confined to a brief summary of the most important points raised by this problem, whilst for details in regard thereto the reader is referred to the study prepared by the International Labour Office.

DEFINITIONS

According to Weyl, there should be included under the designation "occupational diseases" not only those diseases generally caused by the personal activity of the worker, but any frequent manifestation of symptoms affecting a given occupational class. This definition resembles that of Van den Borght, who declares that "occupational diseases are the consequence of long continued action of harmful effects in the exercise of a calling, and that they arise exclusively or with particular frequency amongst the workers in a given industry". Gilbert is of opinion that there should be considered as occupational diseases "those diseases which appear in any given calling with an incidence exceeding the normal, as well as those obviously due to occupational risk".

According to another group of experts, an occupational disease is a disease "related to the exercise of certain callings, in which it originates, and by reason of this it is to be regarded as an occupational risk" (Jouanny), or, again, it is "a continuous and enduring condition arising from a cause likewise continuing and enduring" (Bourgeois), etc.

Paulet has introduced into the definition a further very important element, that is to say, "the far-reaching consequences of fatigue and ill-health caused by the occupation".

The Committee for the Study of Occupational Diseases established in 1902 in Italy defines as occupational diseases "those diseases caused directly and exclusively by the exercise of an occupation, or those diseases which are the inevitable consequence of a given industry", and under Swiss legislation occupational diseases are defined as "all diseases exclusively or essentially due to the action of substances quoted in the list" forming an annex to the law on accident compensation.

Certain definitions even refer to "diatheses", although it is obvious that many disease forms of occupational origin cannot be compared to a diathesis.

Certain of these definitions are open to criticism. For instance, in regard to duration (definitions of Bourgeois and Van den Borght), it is not indispensable that the exercise of a calling should be of "long duration" before the worker develops an occupational disease. On the contrary in certain occupations, young apprentices and temporary workers are most often affected, and in these instances it is the "occasional" rather than the "habitual" exercise of the calling which at times suffices to give rise to the most serious accidents. As regards the "exclusive" element (Italian and Swiss definitions), there are certain affections where occupational etiology does not enter into the question and the trained medical man must always, in making a diagnosis, take into account conditions and predisposition to disease peculiar to the individual. More generally speaking, it is at times very difficult to differentiate with "certainty" and mathematical "accuracy" the rôle played by various causes which have exercised an effect on the system, and to assign to a given disease an origin either "exclusively" or "partially" occupational. Similarly, there cannot be accepted the conception of the disease being the far-reaching consequence of an unhealthy occupation (Paulet). Such is not the case with an infection having a very short period of incubation, or with poisoning, which progresses in a very short lapse of time (poisoning due to theocarbonic acid or benzine, lead colic amongst white lead workers, etc.).

It is likewise difficult to understand how even a trained medical man can
accurately determine the harmful action of one of the substances enumerated in the list (Swiss definition) when the disease or the lesion is due to two or several substances simultaneously present in the workplace. The frequency of these "mixed poisonings" is much greater than is imagined, especially in the modern chemical industry.

The occupational disease, and notably chronic poisoning, occurs by attacks of short duration followed by periods, which are at times fairly long, of at least apparent normal physiological equilibrium. The conception of "slow" poisoning is therefore too narrow, for there are cases in which the absorption of the poison occurs in a relatively short time, yet not so short that they can be considered as accidents in the legal sense of the word.

The conception, which is acceptable in theory, of "absorption", "impregnation", "poisoning", corresponding to three phases of the toxic action of a substance, represents in practice a subtle process which runs the risk of depriving the victim of legal compensation for occupational disease. It is with a view to safeguarding the principle of this right to compensation that for some time back authorities have bestowed a very wide interpretation on the definition of accident, especially in regard to its elements of "suddenness" and "violence" (see below).

The diseases which are of interest for experts in industrial medicine are those affecting exclusively the workers, or again those which, on account of economic and social conditions in which the workers live, show a special tendency to break out amongst them.

The first constitute occupational diseases or "technopathies", the second are "industrial diseases" or ordinary diseases which in certain special conditions assume particular importance.

According to Biondi, those diseases which are the consequence of unfavourable conditions intimately connected with ordinary industrial routine due to multiple and repeated effect but spread over a period of time, may be designated as occupational diseases.

On the other hand, accidents and diseases due to an accident are the consequence of unfavourable causes residing in abnormal, unusual happenings in the course of work, which is interrupted thereby. It is, that is to say, an event of sudden occurrence, occupying a brief space of time, and the manner of occurrence of which cannot be foreseen.

Martin has also provided a definition of "occupational disease" and "industrial disease". The latter, which is common to all workers, is not related to a certain occupation. Its etiology, the circumstances of its occurrence, etc., are conditioned principally by individual factors and indirectly by the work. The occupational disease, on the other hand, exclusively affects certain classes of workers. It is created, so to speak, entirely by a given occupation or by the conditions under which such occupation is effected.

Gilbert, however, when acting as Reporter to the Committee on Occupational Diseases at the Seventh Session of the International Labour Conference (1925), stated that "it is well known that no truly satisfactory definition of occupational disease exists, nor any criteria capable of determining in every case and with accuracy the etiological diagnosis of the disease symptoms encountered."

Finally, certain legislative authorities, belonging chiefly to the United States, consider that they have adequately satisfied the demands for compensation by replacing in the definition the word "accident" by the word "injury". This larger formula, it is true, covers the whole individual pathology, yet it necessitates a number of essential precautions for the exclusion of abuses. If account be taken, however, of the practical results already acquired over a long period (ten years, for instance, in California), it must be admitted that the system in question offers great advantages. Certain countries, notably New South Wales, have even gone so far as to substitute this system for the list previously adopted by them. It is therefore necessary to devote the closest attention to the movement in question with a view to the ultimate attainment of conclusions to be drawn therefrom.

Notification

Legal compensation for occupational diseases of necessity implies notification of diseases entitling the worker to compensation, which is generally effected by a simple and practical system. France, Germany, Great Britain, and certain of the United States provide highly interesting statistics (see section of this article "Statistics") relative to diseases compensated.

Notification also exists in those countries which, up till a few years ago, had no system of insurance for
industrial diseases, in the Netherlands, for instance. It is similarly instituted in those countries which possess systems of compensation for certain diseases not yet included in the list adopted by them.

Declaration implies in these cases collection of data which enable a fairly accurate estimation to be obtained of the incidence of the disease in question in certain industries or groups of industries, with a view to the preparation of adequate legislation relative to prevention and compensation.

It must, however, be frankly admitted that for a long time back authorities on industrial medicine have been unanimous in their opinion that compulsory notification of occupational diseases does not provide accurate information as to the occupational risk to which the workers are exposed, unless it is carried out by all doctors and with all possible care. Unfortunately, the long-existent practice in certain countries (in the Netherlands, for instance, where a doctor's fee is paid for every case notified) does not confirm this hope, and notification can only be effective where it forms one element in a system of insurance.

At the First International Labour Conference (1919), the Committee on Unhealthy Trades considered it advisable to formulate a resolution, ultimately passed by the Conference, expressing the hope that occupational diseases should in every case be notified by the medical profession.

Amongst those countries where notification is compulsory, may be cited: Argentina, Austria, Brazil, France, Germany, Great Britain, Italy, Netherlands, Poland, and several of the United States, etc.

The diseases compulsorily notifiable vary in different countries. In Great Britain, for instance, they include the following diseases: lead poisoning; poisoning by carbon disulphide, aniline, benzine, phosphorus, arsenic, mercury; anthrax; toxic jaundice; epitheliomatosous ulcerations and ulcerations due to chrome and chromates. In France the Decree of 16 November 1929 contains a long list of diseases of occupational nature which must be notified. The list drawn up by the legislative authorities of the Netherlands (Decree of 4 October 1920) is also very detailed.

In the various articles of this *Encyclopædia* there has been quoted as completely as possible the list of countries which require medical authorities to provide notification of the disease in question in each particular case.

## Statistics

By way of example, tables I to V provide some statistics for Belgium, Germany, Ohio (U.S.A.), France and Great Britain.

### Table I. — Belgium

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Cases notified in 1928</th>
<th>Cases compensated in 1929</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead poisoning</td>
<td>38</td>
<td>24</td>
</tr>
<tr>
<td>Anthrax</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table II. — Germany

<table>
<thead>
<tr>
<th>Diseases</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Due to lead or its compounds</td>
<td>3,129</td>
<td>3,329</td>
<td>3,424</td>
<td></td>
</tr>
<tr>
<td>2. Due to phosphorus</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3. Due to mercury or its compounds</td>
<td>23</td>
<td>90</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>4. Due to arsenic</td>
<td>23</td>
<td>51</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>5. Due to benzene or its homologues</td>
<td>113</td>
<td>115</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>and amido-derivatives of the aromatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>series</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Due to carbon disulphide</td>
<td>37</td>
<td>86</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>7. Cancer of the skin due to soot,</td>
<td>16</td>
<td>3</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>paraffin, tar, anthracene, pitch, or</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>similar substances</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8. Chronic dermatitis and chronic</td>
<td>34</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>recurring dermatis due to soot, paraffin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tar, anthracene, pitch, or similar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>substances</td>
<td>37</td>
<td>79</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>9. Glassworkers' cataract</td>
<td></td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Due to X-rays or other radiant</td>
<td>16</td>
<td>3</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>sources of power</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Ankylostomiasis</td>
<td></td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>12. Due to carbon-monoxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Chronic dermatitis and chronic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>recurring dermatitis caused by electric</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>troplating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Serious pneumoconiosis (silicosis)</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>15. Schneeberg disease</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>16. Deafness caused by noise as well as</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hearing bordering on deafness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Various</td>
<td>454</td>
<td>393</td>
<td>442</td>
<td></td>
</tr>
</tbody>
</table>

In 1927 and 1928 the following cases were likewise notified in France: hydrocarbides, 19; aniline and its derivatives, 4; carbon disulphide, 6; chlorine and its organic compounds, 19; hydrocyanic acid,
OCCUPATIONAL DISEASES — 392 —

DEFINITION AND


In table VI are given cases of occupational diseases compensated in Great Britain: The figures relate to cases compensated for the first time in each year in question.

In Switzerland from 1922 to 1927 the following cases of poisoning received compensation (the figures in parentheses denote fatal cases): lead and its compounds, 255 (11); mercury, its salts and amalgams, 54; phosphorus and its compounds, 5; arsenic and its compounds, 4; chrome and chromates, 4; carbon monoxide, phosgen, 26; nitrous gas, 13; cyanogen and its derivatives, 4; sulphuretted hydrogen, 10; mineral acids, 56; alkalis, 8; halogens and organic derivatives, 23 (1); benzine, its homologues and organic derivatives, 92 (4); tar pitch, etc., 4; aliphatic

TABLE III. — OHIO, U.S.A.: OCCUPATIONAL DISEASES FOR WHICH COMPENSATION HAS BEEN REQUIRED FROM 1 JULY 1920 TO 1 JULY 1927

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infections:</td>
<td></td>
</tr>
<tr>
<td>Anthrax</td>
<td>10³</td>
</tr>
<tr>
<td>Glanders</td>
<td>6³</td>
</tr>
<tr>
<td>Dermatitis (oils, dusts, liquids, fumes, gases):</td>
<td>3,065³</td>
</tr>
<tr>
<td>Cancer (tar)</td>
<td>122</td>
</tr>
<tr>
<td>Forms of poisoning:</td>
<td></td>
</tr>
<tr>
<td>Zinc, brass</td>
<td>61¹</td>
</tr>
<tr>
<td>Lead</td>
<td>107⁴</td>
</tr>
<tr>
<td>Mercury</td>
<td>10¹</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>2</td>
</tr>
<tr>
<td>Arsenic</td>
<td>10</td>
</tr>
<tr>
<td>Benzine and its derivatives</td>
<td>74⁴</td>
</tr>
<tr>
<td>Carbon disulphide</td>
<td>3</td>
</tr>
<tr>
<td>Not classified</td>
<td>346⁴</td>
</tr>
</tbody>
</table>

There were also compensated cases of chronic skin disease due to the following substances: lead and its compounds, 6; arsenic and its compounds, 3; chrome and chromates, 26; cyanogen and its derivatives, 15; sulphuretted hydrogen, 2; mineral acids, 84; alkalis, 112; halogens and their organic derivatives, 80; benzine, its homologues and aromatic derivatives, 107; tar, pitch, etc., 35; aliphatic series, 45; various, 251 (of these 40 were due to alkaloids, 80 to turpentine, and 62 to mixed products).

Compensation

It may be said that at the present time public opinion is unanimous in its demand for a solution of the problem of compensating occupational diseases in a reasonable and conciliatory spirit rather than on an abstract legal
basis or within the strict sense of a legal definition.

At the outset this question was stated thus, in accordance with common law: the worker who is a victim of an occupational disease had to furnish the legal authority with proof of negligence or guilt on the part of his employer, and of the occupational origin of his injury. However, to avoid loss of time and money, the possibility of an adverse decision, and at times even the loss of his employment, the worker was often induced, unless he was totally incapacitated, to renounce all claim to the compensation to which he was entitled.

The principle of occupational risk being now universally recognised, the victim of an industrial accident is assured of really effective protection, yet it must be admitted that this protection is not as extensive and as general in the case of the victim of occupational disease.

There are yet, at the present time, however, many countries in which no compensation is granted to a healthy worker, or no indemnity paid to the dependants, in the case of his health being destroyed by an industrial poison in a few months or years, or in the case of loss of life, even where the employer neglects to adopt the most elementary precautions or omits to observe the regulations. Further, such an occurrence is even possible in countries which possess a system of compensation whenever their list does not comprise the toxic product in question, or whenever such product is used, produced or liberated in course of an industrial operation not mentioned in the said list.

### TABLE VI. — GREAT BRITAIN

<table>
<thead>
<tr>
<th>Diseases</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthrax</td>
<td>36</td>
<td>8</td>
<td>26</td>
<td>29</td>
<td>23</td>
<td>25</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>Poisoning by mercury or its sequelae</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Poisoning by phosphorus or its sequelae</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Poisoning by arsenic or its sequelae</td>
<td>199</td>
<td>146</td>
<td>137</td>
<td>236</td>
<td>285</td>
<td>234</td>
<td>177</td>
<td>134</td>
</tr>
<tr>
<td>Poisoning by lead or its sequelae</td>
<td>12</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poisoning by bencene, its homologues or sequelae</td>
<td>57</td>
<td>9</td>
<td>90</td>
<td>42</td>
<td>12</td>
<td>18</td>
<td>17</td>
<td>37</td>
</tr>
<tr>
<td>Poisoning by nitro-amido derivatives of bencene and their homologues or sequelae</td>
<td>37</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Poisoning by dinitrophenol or its sequelae</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Poisoning by nitrous gas or its sequelae</td>
<td>19</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Poisoning by tetrachlorothane (&quot;dope poison&quot;)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poisoning by carbon disulphide or its sequelae</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Poisoning by nickel carbonyl or its sequelae</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Poisoning by guinosa kamasi or its sequelae</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
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<tr>
<td>Poisoning by manganese</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Dermatitis caused by dust or liquids</td>
<td>396</td>
<td>131</td>
<td>156</td>
<td>346</td>
<td>192</td>
<td>597</td>
<td>712</td>
<td>909</td>
</tr>
<tr>
<td>Ulceration of the skin due to dust or liquids</td>
<td>91</td>
<td>45</td>
<td>36</td>
<td>70</td>
<td>58</td>
<td>63</td>
<td>58</td>
<td>31</td>
</tr>
<tr>
<td>Ulceration of the mucous membrane of the nose and mouth due to dusts</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Epithelomatous cancer</td>
<td>16</td>
<td>19</td>
<td>14</td>
<td>15</td>
<td>12</td>
<td>49</td>
<td>85</td>
<td>55</td>
</tr>
<tr>
<td>Corneal ulceration</td>
<td>17</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cancer of the scrotum (chimney sweeps' cancer)</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>27</td>
<td>28</td>
<td>2</td>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>Ulceration due to chrome or its sequelae</td>
<td>63</td>
<td>74</td>
<td>16</td>
<td>27</td>
<td>32</td>
<td>17</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Compressed air disease or its sequelae</td>
<td>12</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Glass workers' cataract and cataract due to radiation of molten or red hot metal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankylostomiasis</td>
<td>1</td>
<td>2</td>
<td>14</td>
<td>13</td>
<td>12</td>
<td>10</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>Miners' nystagmus</td>
<td>2,865</td>
<td>1,013</td>
<td>4,092</td>
<td>3,883</td>
<td>3,971</td>
<td>3,445</td>
<td>3,171</td>
<td>1,892</td>
</tr>
<tr>
<td>Sub-cutaneous cellulitis of the hand (&quot;beat hand&quot;)</td>
<td>763</td>
<td>806</td>
<td>1,183</td>
<td>1,344</td>
<td>1,197</td>
<td>1,154</td>
<td>1,154</td>
<td>2,461</td>
</tr>
<tr>
<td>Sub-cutaneous cellulitis, or acute bursitis over the knee (&quot;beat knee&quot;)</td>
<td>1,292</td>
<td>806</td>
<td>1,793</td>
<td>2,540</td>
<td>2,743</td>
<td>2,600</td>
<td>1,392</td>
<td>2,202</td>
</tr>
<tr>
<td>Sub-cutaneous cellulitis, or acute bursitis of the elbow (&quot;beat elbow&quot;)</td>
<td>133</td>
<td>101</td>
<td>102</td>
<td>392</td>
<td>309</td>
<td>302</td>
<td>303</td>
<td>355</td>
</tr>
<tr>
<td>Inflammation of the synovial lining and tendon sheaths of the wrist joint</td>
<td>75</td>
<td>78</td>
<td>186</td>
<td>192</td>
<td>190</td>
<td>204</td>
<td>174</td>
<td>95</td>
</tr>
<tr>
<td>Writers' cramp, telegraphists' cramp and cotton twisters' cramp</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Silicosis (refractory Industries)</td>
<td>44</td>
<td>44</td>
<td>62</td>
<td>42</td>
<td>37</td>
<td>34</td>
<td>35</td>
<td>37</td>
</tr>
</tbody>
</table>
The worker is, in numerous unhealthy trades, continuously in "imminent danger", even when he takes the most thorough precautions with a view to protecting himself against the injurious effect of poison or infection insidiously hidden in the product manipulated. It has already been shown (see article "Blood and Industrial Poisonings") that while some light has penetrated the obscure depths which still screen from view the exact mechanism of the receptivity of the body to industrial poisonings, there is still much ground to be covered before scientific effort succeeds in dispelling this obscurity. None the less, until such time elapses, it is neither logical nor equitable to refuse any compensation to those workers who are victims of occupational injury for the sole reason that the cause of the latter is not included in a list the form of which is usually unduly restricted.

It is somewhat difficult to understand from the medical point of view the necessity for differentiating between the occupational accident and the occupational disease, since the etiology — work — is in each case the same, and the resultant injury is also the same: incapacity or death, whether the disease form be of a medical or surgical nature. In both cases it is a question of an attack on the health of the individual. Without, however, insisting further on this point, it seems that it would be truly illogical to conceive of a difference between a case of accidental poisoning due to sudden liberation of toxic fumes or gas and a case of slow poisoning due to the same industrial gas. Similarly, it would be illogical to provide compensation in the case of injury caused by a toxic substance enumerated in a list whilst no compensation is provided for cases due to a substance not comprised in the list and affecting a worker employed in the same workshop as another whose accident (disease) entitles him to insurance benefits!

In the case of a whole series of injuries in regard to which the occupational origin could be proved by medical examination of the cases in question, there is hesitation in admitting the claim primo jure, a point of view which leaves out of account the fact that very often the worker is unable to defend himself against poisonous or harmful fumes and dust where no effective method of eliminating them is provided unless he gives up his work entirely. Likewise, the fact is often overlooked that in many cases colourless and inodorous fumes which escape from pipes and apparatus may poison the worker without his being at all aware of their presence, even from the very outset of their action, which takes effect even with minimal doses.

Appeal is also made to the worker's carelessness and his neglect in regard to personal cleanliness, facts likely to favour the development of occupational disease or to increase the danger of poisoning. These facts must be recognised, yet, on the other hand, how many cases of occupational poisoning can be quoted as having occurred amongst individuals who exercised care, paid attention to bodily cleanliness, and were aware of the danger inherent in the substances manipulated? To go even further, how many experts, and even employers, have suffered from the effects of substances handled in ignorance, at times, as to the composition of these, and, at times, as to their harmful or toxic properties?

Modern industry employs increasingly products furnished by organic chemistry, and introduced into industrial practice without any previous study having been made in regard to their physiological action. There have besides been met with cases of poisoning caused by unexpected reactions having no connection whatsoever with the industrial operations in question (liberation, for instance, of phosphorus in the form of phosphoric acid), even the watering with hot water of residual heaps of molten ore containing phosphorus. It is only by means of long and extensive daily practice that it is possible to acquire accurate knowledge of the toxic action of products at first considered inoffensive or only slightly toxic.

Legislative authorities have always been faced with the difficulty of defining the object of insurance, given the necessity for specifying the substance by distinguishing as far as possible between that due to occupational disease and that due to causes of ordinary disease.

Jurisprudence, ordinary practice and theory have all sought to endow occupational disease with a special character differentiated from accident by certain characteristics which Peri summarises as follows:

Origin. — So far from constituting an exceptional occurrence, the disease is the consequence of routine work.

Nature and moment. — It may be foreseen by very reason of the work in question: it is fatal in the sense that it depends on the repetition of the same work, setting up an action which is constantly and imperceptibly manifesting itself rather than in one single occurrence.
Pathogenesis. — It is generally slow and insidious in origin, and difficult to determine.

Evolution. — It develops slowly, and may remain unnoticed until the outbreak of symptoms which are at times of sudden appearance.

Methods of work. — The methods of work determine the incidence in a given industrial centre, the anomalies of evolution, the gravity of the forms presented, the characteristics of the symptoms, the development of these symptoms, and the progress of a common disease.

Individual susceptibility. — The pathological cause does not evoke amongst certain workers noteworthy effects; amongst others it sets up very grave injuries.

Death. — Death is the result of a constant series of accidents, the repetition of which is bound to lead to this issue, since each of them diminishes the force of resistance of the system, with the result that each new accident is more serious than the former.

If the question be regarded exclusively from the point of view of "compensation", it must be recognised that the diagnosis is essentially medico-legal, since it is a question of estimating the medical character of the injury with the particular object of presenting a legal report (Biondi). Yet a medico-legal definition in each particular case presents great difficulty. In fact, though it may be easy to specify that a given cause of injury may, by multiple and repeated action connected with the normal progress of the work, cause a given lesion, it may happen, on the other hand, that the doctor is not in a position to prove that this lesion really depends on this particular cause of injury which has exerted its effect at a more or less distant date. To avoid repetition, there shall be examined briefly the question of compensation for infectious and parasitical diseases, since consideration of this question provides opportunity for analysing certain elements of the definition of accident in regard to which there has been, and still is, much discussion.

The question of assimilating these diseases to accidents or occupational diseases for the purposes of insurance is still highly uncertain and confused. In certain countries the legislative authorities have inscribed some infections in their list of occupational diseases (Switzerland, Great Britain, etc.), yet later — as, for example, in Switzerland — the medical authorities refused to designate them as industrial accidents. In Italy infectious diseases are also regarded as accidents (this is the case in regard to anthrax, in virtue of section 14 of the Act on insurance for occupational diseases). Ankylostomiasis, on the other hand, figures in the list annexed to this Act.

The question, which is of little consequence theoretically, affects in practice general or local infections due to specific germs, but, as regards infections, as in the case of other disease forms, a clear schematic differentiation between these and accidents is not possible. There exist too many transition forms on the border line between disease and accident which complicate the problem.

It appears that at the present moment it would be much simpler to include these diseases in the list of those entitling the victim to compensation, rather than engaging in discussion as to whether in each particular case the conditions required by the law on accidents are fulfilled. However, in many countries preference still tends towards following the system which was adopted at the time when the law existed only in regard to accidents, and infectious or parasitical diseases are compensated by an extensive interpretation, at times even a slightly forced interpretation, of the definition of an accident. It is chiefly the terms "sudden" and "violent" in the definition which have been made the subject of discussion by medical and legal authorities. At the present time the opinion has been generally accepted that the words "violent action" should not exclusively and essentially designate "a lesion of mechanical origin."

The difficulty of interpretation has been chiefly in regard to the term "violent". Yet agreement has now been reached in regard to the fact that "violence" in the question under discussion refers not only to the intensity but also to the potential unfavourable effect of the agent, but not to the lapse of time during which this agent exercises its effect on the system. Further, the term "violence" describes not only an unfavourable cause of mechanical origin but also a body or phenomena acting by reason of their very nature in an intense manner because of some inherent energy which manifests itself and which is capable of exercising an effect on the system attacked in an intense fashion. The action of solar radiation may in consequence be "violent" and likewise the action of a current of cold air or, again, that of a toxic substance when the harmful force liberated is sufficiently intense to cause death or disease, even when such action only exercises its effect during a very short time.
It has been fairly easy to extend this conception to cover forces of a biological order such as infections and parasites. In fact, these agents possess the capacity of setting up phenomena of a special character and notably a morbid condition. The disease agents introduced into the body constitute forces which by multiplication become causes of injury to the system.

The conception of "violence" in this case is identical with that of "virulence" especially when this capacity for harm is exercised by a small number of germs which have penetrated the body on one or several occasions but within a short lapse of time. The mechanism of entry into the body must be left out of consideration (traumatic lesion or otherwise, digestive or respiratory passage), for it is here a question of a violent occurrence represented by pathogenic germs capable of exerting "violent action" after having penetrated into the body.

There must be recalled in this connection the violent action on the system of certain toxic products. In this case it must be admitted that the only criterion should be the nature of the substances which have penetrated into the system, without requiring that such penetration is brought about by means of violent lesions.

As regards the other aspect of the question, that of duration of the action, it is hardly necessary to recall the lengthy discussion which has been going on with a view to determining the length of period designated by the expression "suddenness" in regard to this action. The idea of a sudden or instantaneous action has been abandoned, and use is now chiefly made, in accordance with the Italian interpretation (Carneluti, Borri), of the words "rapidity", "concentrated cause", remembering that the harmful action may exert its effect also by repeated contact during a short lapse of time and not necessarily on one single occasion. It may indeed be asked whether such a short lapse of time is to be calculated in minutes or hours or days. It is nevertheless true that in regard thereto it is necessary to adopt a practical attitude and that the limit in question is well indicated by the very conditions under which the harmful action exercises its effect. The length of a shift already provides a limit in time to the action of the harmful effect and in consequence concentrates the risk as regards time. Diez, who has made a careful study of this problem, enquires whether it would not be advisable to adopt a chronological unit as a standard of measurement of occupational activity, and a unit of measure of the pathological action representing a cause of damage to the system.

Finally, where the worker has been exposed during the course of a day's work, either uninterrupted or broken by short enforced rest periods, to a harmful cause which has given rise to disease phenomena without any subsequent repetition or renewal of such harmful agent in the course of successive periods of work, it may be admitted that in these circumstances the conditions of intensity required by the words "violent action" in the definition of an accident are complied with.

Any infectious or parasitical disease may, however, occur as the consequence of a single inoculation of germs or during a short period of contact between the individual and the source of infection. It is certainly difficult to determine exactly when the individual exposed to contagion has contracted the disease, or "during how long" he was exposed to contagion, except in the case of obvious localisation of infection. It is the occurrence in the course of work which must be insisted on rather than the "violent cause", since in practice many forms of infection occurring amongst workers are most usually of occupational origin: anthrax (hides and skins, hair); glanders (stableboys, veterinary surgeons, etc.); the possibility and probability of infection once admitted, any other considerations become superfluous.

The principle that the cyto-microbial struggle being engaged in within the body by the disease agent, once it has entered into contact with the tissues, may be considered as a violent lesion has been accepted in regard to tuberculosis. When the Koch bacillus enters a healthy body in limited number it there sets up a benign affection which may remain in a latent state even permanently. It is only when the germ invades the body in massive doses that the disease breaks out. Yet amongst individuals affected by a form of the bacillus in a latent state, the outbreak of tuberculosis occurs when the virulence of the disease agent has been increased, or when new germs penetrate into the system and are superimposed on those already there; re-infection breaks out and is manifested by the characteristic symptomology. The assistance of a traumatic cause acting on any part of the body is not an
essential element to the outbreak of a bacillary lesion. From the medico-legal point of view it would be, as stated above, necessary to prove that the violent cause (tuberculosis bacilli) has set up the disease form encountered "in the course of work". This proof is sometimes difficult to effect, for the infection of a worker by tuberculosis may equally occur outside working hours. Yet this difficulty should not discourage efforts to determine conditions providing a basis entitling workers to compensation. Carnelutti is of opinion that it is necessary to overcome a current instinctive attitude of repugnance which leads to traumatic lesions only being considered as accidents exclusive of those habitually designated as "diseases". In order that adequate compensation should be provided it is therefore essential to prove that the "generic" risk to which every man is exposed may become, as for example in the case of tuberculosis, a "specific" risk.

Peri, who has made a very thorough study of this question, is of opinion that all forms of tuberculosis amongst workers engaged in industrial processes during which the work exposes an effect capable of reducing means of organic resistance and indirectly favouring the entrance of the tuberculosis bacillus, do not come within the number of lesions covered by the definition of industrial accident, but they may, however, be included thereunder when there is a presumption, if not a certainty, that the tubercular bacillus has penetrated into the body during work in "massive doses".

If Gilbert's definition is accepted, tuberculosis becomes occupational in origin when found to occur with particular frequency amongst certain categories of workers. It is then a question, according to Peri, of workers occupied at work in the course of which a traumatic action exerts slow but constant effect on a certain part of the thorax: boatmen on the Rhône (Pernoud); alabaster workers (Pieraccini); persons engaged in nursing tubercular patients or handling the linen of such patients rich in infectious germs: nurses (Devoto); nursing sisters, nurses (Peri); laundry workers (Landouy); rag-pickers (Brouardel), etc. In other cases tuberculosis meets with a centre more favourable to its development by reason of lesions of another nature set up by causes of slow effect. The risk here is generic, and tuberculosis represents a lesion directly superimposed, not during work, but on a centre rendered susceptible by the effect of the occupation.

This is so, for instance, amongst workers engaged in confined and overcrowded workshops where light is insufficient and often artificial, or where the nature of the work demands the use of coal stoves: tailors, dressmakers, seamstresses, ironers and embroidery-workers, etc. (Romme, Allaria, Magrini); in overheated places with abundance of dust and atmosphere vitiated, for example, by tobacco smoke: postal and telegraph employees (Brouardel, Hericourt); hairdressers, clerks, waiters, etc.; in places with a high humidity rate: workers in spinning-rooms, laundry-workers, miners (Monti); in places with very high or low temperatures: metallurgical workers, glass-workers, workers in the cold storage industry; in places where toxic gases or fumes are given off: chemists, etc.; in places were dusty vegetable origins are present: coal, flour (Koelsch, Courmont), tobacco (Peri, Stephani), textiles (Durozier), sugar-refiners (Bernheim); or animal (silk, wool, horn, tortoise shell (Hirt); or mineral (stoncutters, grinders, polishers, etc.); in professions where the worker is obliged to assume a posture which limits thoracic expansion: shoemakers, watchmakers, bookbinders, etc.; finally, in occupations where the outbreak of tuberculosis is favoured by occupational poisoning: workers handling lead, arsenic, mercury, copper, zinc, etc.

Systems of Compensation

With a view to solving the problem of compensation, legislative authorities have in the different countries had recourse to systems which are based on three general principles:

(a) Admission that all diseases may be of occupational origin and their total assimilation to diseases (system of universal insurance for disease and invalidity);

(b) Admission that occupational diseases represent an occupational risk and compensation for these on the same basis as that of industrial accidents;

(c) Compensation in accordance with special legislation.

(d) The first of these principles without doubt presents many advantages. It has been seen that besides occupational diseases ("technopathies") there exist "industrial" diseases finding in the occupation their primary motive; that very often there is no demarcation line between the occupational disease and the ordinary disease; that it is often difficult to prove that the disease has been actually caused by the occupational activity of the victim.
though it is possible to determine in many cases just to what degree its development has been aided. The system of disease insurance eliminates the necessity of etiological diagnosis, and hence the necessity for establishing a medico-legal basis for estimation of the injury (incapacity for work). It eliminates likewise other difficulties; discrimination in complex cases, enquiry into the influence of the former state of health of the individual, his heredity, his manner of living, his lack of cleanliness or even his carelessness; it does away with the difficulty of distributing responsibility amongst various employers; it provides insurance for a larger number of workers, and compensates a whole series of slight illnesses of a somewhat evanescent nature which exist on the borderline of occupational pathology, but which in practice represent a highly important cause of absence and a starting point for many occupational diseases.

On the other hand the system of disease insurance has been open to several criticisms: first, compensation for occupational diseases in accordance with this system imposes on industry in general a burden for compensation which properly belongs to but a few of them; disease insurance leads to appeal for financial assistance to the workers and often also to the State; that is to say, to the whole social community, the most important part of which is represented by the working classes, with the result that the burden rests on a group which is already the victim of occupational disease properly to be considered as a risk inherent in industry, and which ought not to be borne even partially by the workers. Yet that is not all. The injury of occupational origin from judicial motives, both from the medical and human standpoint, ought to be compensated on a more generous scale than ordinary illness or invalidity. In certain countries, however, the insurance scheme in question only provides the victim with a maximum period of one year). No invalidity benefit is taken into consideration unless the disease lasts over twenty-six weeks and causes incapacity amounting to over two-thirds. This system requires a long waiting period and in the case of death only provides payment of a subsidy towards funeral expenses, and no allowance is granted to dependants.

With a view to eliminating certain of these disadvantages, several authorities have studied a system of compensation coming within the scope of sickness insurance with a special scheme in favour of workers in unhealthy trades who are victims of occasional diseases. In this case the burden of compensation is placed on a group of industries in which workers are employed who are exposed to similar risk and whose employers are obliged to pay a higher premium proportional to the gravity of the risk involved. In this way the employer is stimulated to improve healthy conditions in his industry with a view to obtaining entrance into a lower category from the point of view of risk than that in which he is actually classified (Carozzi, Sand, etc.).

(b) Legislative authorities were led to recognise the necessity for affording occupational disease a special place within the scope of their social insurance schemes; but on the one hand, since they possessed no definition permitting them to describe "occupational disease", and on the other hand they were faced with the difficulty of establishing an equitable system of compensation, a solution was sought by avoidance of the obstacle in refraining from formulating any definition, and restriction to the framing of a list of those occupational diseases which are on the intention to compensate, such list being annexed to the law on compensation. Hence arose the system of the list and recognition of a presumption in favour of the worker affected by an occupational disease inscribed on the list. In this way it was possible to obviate the necessity for a case by case method which in most cases it was impossible to furnish.

In certain countries for reasons of convenience, legislative authorities proceeded to extend the law on accidents to cover occupational diseases thus defined. In others, on the contrary, preference was given to a system which consisted in defining accident in such a way as to cover at the same time occupational disease.

The situation created in regard to infectious or parasitical diseases of occupational origin has already been referred to above. Nevertheless, under this system the very important part of the burden of compensation inevitably rests on the shoulders of the victim. In fact many occupational diseases which are on the borderline of ordinary disease forms thus receive no compensation or only receive it under a system of general sickness insurance. It is therefore only right that the injuries caused should be compensated in as wide and rapid a manner as possible in these cases without any argument as to their occupational origin.

Attention must now be bestowed on the form to be given to the list in question — already the subject of a certain amount of discussion and criticism.

Three different conceptions at least emerge.

The first is confined to inclusion of a series of diseases or lesions affecting workers without any reference to the clinical picture or to the various occupations involved. In the first column of the list certain diseases are enumerated, as for instance lead poisoning, mercury poisoning, etc., and their sequelae; in the second column there is a note to the effect that the injuries in question affect any worker engaged on any work involving the manufacture or use of lead, its compounds or alloys; "of mercury, its amalgams, salts, etc."

The second conception consists in enumerating in the first column certain symptoms of the disease legally entitled to compensation (for instance, of lead or mercury poisoning), and in the second
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column corresponding point by point to these is detailed a list of the industries or operations likely to give rise to the said diseases. For instance, the French system of legislation provides compensation for paralysis, rheumatism, colic, cachexia, etc., due to the poisoning when such symptoms are found amongst workers engaged, for example, in metallurgy and refining of lead, tinning, manufacture of salts of lead, manufacture of pottery and china with lead enamels, etc. In consequence any disease showing symptoms not included in the list, or any clinical picture described in the list but not occurring in an industry mentioned in the second column, does not entitle the worker to compensation.

The third method is that followed in Swiss and Finnish legislation, and limits compensation to those injuries caused "essentially or exclusively" by one of the substances enumerated in the list.

These three different conceptions, however, provide subject for reflection. It would appear obvious that such lists ought to be made the subject of periodical revision and that they must be kept in continuous revision by doctors, employers and workers with a view to detecting at an early stage the occupational types of disease and rendering possible the immediate application of measures of prevention required. In this connection the French list possesses the advantage of constituting a highly useful guide for medical practitioners. Yet it has the disadvantage of fixing artificial limits.

In regard to propaganda it should be recalled that the German list is followed by a circular providing all requisite information as to what is implied by the formula adopted in the first column of the list (without, however, presenting the point of view in question in the form of a restrictive formula).

(c) The third principle involves special legislation such as that adopted, for instance, in Belgium. Compulsory insurance for industrial establishments coming within the law excludes the intervention of insurance companies on the ground that such insurance would eliminate the individual responsibility of the heads of undertakings and creates an insurance fund for providing indemnity for cases of occupational disease entitling the worker to compensation. Under this law a double list has been established giving, on the one hand, the various branches of industry coming within the law, and on the other those diseases which in each category of industrial work entitle the worker to compensation.

The insurance fund is controlled and guaranteed by the State. The annual contribution of heads of industrial undertakings is fixed by Royal Decree.

The Executive Committee entrusted with the administration of the fund is aided by a technical medical committee in which the employers' and workers' interests are duly represented. This Committee proposes cases which it estimates should be subjected to the law and also fixes the designation of disease forms to be mentioned in the list. It further assesses the amount of contributions.

When a worker is affected by an occupational disease contracted in one of the establishments in question he makes his claim for compensation to the fund which, after enquiring into the matter, confirms or rejects it, and having confirmed it, communicates its decision to the worker in question. In the case of a negative decision, appeal may be had to the legal authorities with a view to obtaining an award on the subject.

For details as to liberty in the choice of a doctor, compensation, injury, etc., reference should be made to the law.

There is one serious aspect of the problem which legislative authorities cannot afford to overlook, namely, the "allocation of responsibility" of the employers when the worker becomes the subject of an occupational disease.

The question is certainly more complicated than in the case of an accident. It is merely in the case of a worker who is the victim of an occupational disease having passed from one factory to another in the same industry that the question is not difficult of solution. It is a very different question when the worker affected has passed from a dangerous industry to another offering less occupational risk, or to another of quite different character. It is often difficult to attribute the correct share of responsibility for the origin of the lesion which should devolve on the different occupations, since it is often impossible to ascertain the starting point of the illness.

Further, it is essential to determine up to what point in time the employer is responsible for the injury or the disease contracted in the course of work by a worker whom he has employed. Apart from certain well-known infections, it is at times impossible to determine the exact date of the onset of the disease and the various circumstances which may have influenced its development. However, admitting the possibility of specifying the moment of the first onset on the system, is it always possible to ascertain at an early stage the importance of the sequelae which a given disease may involve? There have occurred cases accurately studied in which pathological phenomena, more especially in the case of chronic poisoning, have occurred after a fixed period (in general a year) and at a time when the patient had left the dangerous occupation.

The question of allocating responsibility for the risk between different heads of establishments in which the patient has been employed during the twelve months preceding the outbreak of the disease constituting another source for an industrial dispute and a lawsuit. In Great Britain, thanks to the special type of judicial institutions of the country, such disputes are, however, fairly rare. But it is not always the case, however. With a view to surmounting this difficulty the Belgian legislative authorities have sought the solution above referred to. They have thus done away with the necessity for
enquiring into the question of individual responsibility by not insisting that compensation should be paid directly by the employer to the employee, and have also reduced to a minimum motives for legal proceedings, by providing for the intervention between the interested parties of a competent neutral body to solve their difficulties.

In regard to the **international aspect** of compensation for occupational diseases, a Draft Convention was adopted in 1925 by the Seventh Session of the International Labour Conference. This Draft is extremely simple. Article 1 demands for victims of occupational disease or their dependants compensation in accordance with the general principles of national legislation relating to compensation for industrial accidents. The rates of such compensation shall not be less than those prescribed by the national legislation for injuries resulting from industrial accidents. Subject to this provision, each Member in determining in the national law or regulations the conditions under which compensation for the said diseases shall be payable and in applying to the said diseases legislation in regard to compensation for industrial accidents may make such modifications and adaptations as esteemed expedient.

Article 2 provides that each Member undertakes to consider as "occupational diseases" those diseases and poisonings produced by the substances set forth in the schedule appended to the Draft Convention (reproduced at the top of this page) when such diseases or poisonings affect the workers engaged in the trades or industries placed opposite in the said schedule and resulting from occupation in an undertaking covered by the said legislation.

This Convention, which came into force on 1 January 1931, was ratified by 1 July 1930 by the following countries: Austria, Belgium, Bulgaria, Cuba, France, Finland, Germany, Great Britain, Hungary, India, Irish Free State, Japan, Latvia, Luxemburg, Netherlands, Norway, Portugal, Sweden, Switzerland, and Yugoslavia.

It is not possible here to enter into other questions connected with the problem of compensation, that is to say training of doctors, drawing up of medical certificates to be forwarded to the competent authority, etc.

**BIBLIOGRAPHY**

There exists a very abundant bibliography on this subject. See the periodical publication of the **INTERNATIONAL LABOUR OFFICE** entitled *Bibliography of Industrial Hygiene* and the report presented to the International Labour Conference in 1934, *Workmen’s Compensation for Occupational Diseases*.

**APPENDIX**

In table I is given a list of the laws and Decrees issued in the various countries in regard to compensation for occupational diseases. It has not been possible to give in this article in their original form the national lists of occupational diseases compensated. It seemed, however, advisable to attempt to assemble in a single table the disease forms inscribed on the said lists (see table III). In order to understand this table account must, however, be taken of the fact that the causes, etc., enumerated in the first column are only intended to facilitate research and that it is the second and third columns which resemble closely the formula adopted by the legislative authorities enumerated in the fourth column. The formulae adopted in the second column therefore correspond to those inscribed by the legislative authorities in the first column of their national list, while those of the third column refer to the formulae which the national authorities have inscribed in the second column of their list.
### Table I. — Legislation

<table>
<thead>
<tr>
<th>Countries: (Countries which have ratified the 1925 Convention)</th>
<th>Insurance for occupational diseases</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Europe</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulgaria *</td>
<td>Law 6 March 1924 and Regulations 25 June 1924.</td>
<td></td>
</tr>
<tr>
<td>Finland *</td>
<td>Resoln 2 July 1926.</td>
<td></td>
</tr>
<tr>
<td>Germany *</td>
<td>Order 11 Feb. 1929.</td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>Laws No. 561 of 1914 and No. 2114 of 11 March 1920, codified in 1929.</td>
<td></td>
</tr>
<tr>
<td>Hungary *</td>
<td>Order, 19 April 1926. Laws Nos. 21 of 1927 and 30 of 1928.</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>Royal Order No. 928. 13 May 1929.</td>
<td></td>
</tr>
<tr>
<td>Latvia *</td>
<td>Laws 1 June 1927 and 28 May 1929.</td>
<td></td>
</tr>
<tr>
<td>Luxemburg *</td>
<td>A.G.O. 30 July 1928.</td>
<td></td>
</tr>
<tr>
<td>Netherlands *</td>
<td>Law 2 July 1928.</td>
<td></td>
</tr>
<tr>
<td>Portugal *</td>
<td>Decree of 9 March 1929.</td>
<td></td>
</tr>
<tr>
<td>Sweden *</td>
<td>Laws 14 June 1929-12 Sept. 1930 and 7 Nov. 1930.</td>
<td></td>
</tr>
<tr>
<td>Yugoslavia *</td>
<td>Law 14 May 1922.</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>Law 29 May 1927. <strong>Silicosis: Miner's Pneumatis Act of 1919, amended by the Consolidation Act No. 33 of 25 July 1929 and by the Amendment Act of March 1929.</strong></td>
<td></td>
</tr>
<tr>
<td>South Africa *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 1. — LEGISLATION (continued)

<table>
<thead>
<tr>
<th>Countries (<em>Countries which have ratified the 1925 Convention</em>)</th>
<th>Insurance for occupational diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>South-West Africa</strong></td>
<td>Proclamation No. 27 of 15 Nov. 1924.</td>
</tr>
<tr>
<td><strong>Southern Rhodesia</strong></td>
<td>Law No. 17 of 30 May 1930.</td>
</tr>
<tr>
<td><strong>North America</strong></td>
<td></td>
</tr>
<tr>
<td><strong>United States:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Federal Government</strong></td>
<td></td>
</tr>
<tr>
<td><strong>California</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Columbia (District of)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Connecticut</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Hawaii</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Kentucky</strong></td>
<td>Law of 1916, ch. 33, sec. 1, amended in 1918, ch. 176 in 1922, ch. 50 and in 1924, ch. 79.</td>
</tr>
<tr>
<td><strong>Massachusetts</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Minnesota</strong></td>
<td>Law of 1921, ch. 82, pt. 2, sec. 67, amended in 1923, 1925.</td>
</tr>
<tr>
<td><strong>New Jersey</strong></td>
<td>Law of 1911, ch. 55, completed in 1924, ch. 124, sec. 2, in 1926.</td>
</tr>
<tr>
<td><strong>North Dakota</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Philippines</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Porto Rico</strong></td>
<td>Law No. 85 of 1928, sec. 3.</td>
</tr>
<tr>
<td><strong>Wisconsin</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Canada:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Alberta</strong></td>
<td>Law 21 March 1928.</td>
</tr>
<tr>
<td><strong>British Columbia</strong></td>
<td>Law 21 May 1926, amended in 1927.</td>
</tr>
<tr>
<td><strong>Manitoba</strong></td>
<td>Law 27 March 1930, amended in 1928.</td>
</tr>
<tr>
<td><strong>New Brunswick</strong></td>
<td>Order 1 Jan. 1929, amended in 1924.</td>
</tr>
<tr>
<td><strong>Nova Scotia</strong></td>
<td>Law 21 April 1915, amended in 1919 and 1923.</td>
</tr>
<tr>
<td><strong>Ontario</strong></td>
<td>Law 1 May 1914, amended in 1926. Regulation No. 99, approved 20 June 1929.</td>
</tr>
</tbody>
</table>

| **Federal Longshoremen’s and Harbour Workers’ Comp.** (44 Stat. 1424 (1 July 1928).) |
| **Law 1915-1916, amended in 1924, ch. 261 (Civil Federal Employees).** |
| **Stat. 1917, ch. 586, as amended 1919, ch. 471.** |
| **45 Stat. 600 and 44 Stat. 1424 (1 July 1928).** |
| **Gen. Stats. 1918, sec. 5888 as amended 1927, ch. 307, sec. 7.** |
| **Rev. Laws 1925, ch. 269, sec. 3604.** |
### TABLE I. — LEGISLATION (continued)

<table>
<thead>
<tr>
<th>Countries (Countries which have ratified the 1925 Convention)</th>
<th>Insurance for occupational diseases</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Central and South America</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolivia</td>
<td>Laws 19 Jan. 1924 and 18 April 1926.</td>
<td>—</td>
</tr>
<tr>
<td>Brazil</td>
<td>Decrees 15 Jan. and 12 March 1919.</td>
<td>—</td>
</tr>
<tr>
<td>Chile</td>
<td>Regl. 21 April 1927.</td>
<td>—</td>
</tr>
<tr>
<td>Ecuador</td>
<td>Draft Regulation (Law No. 305 of 30 Sept. 1921).</td>
<td>—</td>
</tr>
<tr>
<td>Guatemala</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>San Luis de Potosi</td>
<td></td>
<td>Decree No. 308 of 1923.</td>
</tr>
<tr>
<td>Vera Cruz</td>
<td></td>
<td>Law No. 19 of 30 May 1923.</td>
</tr>
<tr>
<td>Yucatan</td>
<td></td>
<td>Law 24 June 1924.</td>
</tr>
<tr>
<td>Nicaragua</td>
<td></td>
<td>Law No. 270 of 4 May 1925.</td>
</tr>
<tr>
<td>Panama</td>
<td></td>
<td>Law 13 May 1930.</td>
</tr>
<tr>
<td>Paraguay</td>
<td>Law No. 606 of 21 Aug. 1927 (List to be published later).</td>
<td>—</td>
</tr>
<tr>
<td>Venezuela</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Federated Malay States</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India *</td>
<td>Laws of 1923 and of 1926. Notification of 30 Sept. 1926.</td>
<td>—</td>
</tr>
<tr>
<td>Japan *</td>
<td>Laws of 1911 and of 1922. List appeared in 1916.</td>
<td>—</td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland</td>
<td>Law 5 Jan. 1916, amended in 1925, 5 Nov. 1925 and 22 May 1930.</td>
<td>—</td>
</tr>
<tr>
<td>Tasmania</td>
<td>Law 15 Jan. 1929 (Mines).</td>
<td>—</td>
</tr>
<tr>
<td>Victoria</td>
<td>Laws 6 Sept. 1915 and 27 Dec. 1928.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Law 31 Oct. 1922.</td>
</tr>
<tr>
<td>Causes of injury and certain effects</td>
<td>Diseases or affections in accordance with the national law</td>
<td>Occupations or substances mentioned in the national lists</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>------------------------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>acids</td>
<td>Poisoning by sulphuric, hydrochloric and hydrofluoric acids.</td>
<td>Any operation involving the use or direct exposure to sulphuric, hydrochloric or hydrofluoric acid and their fumes.</td>
</tr>
<tr>
<td>alcohol poisoning</td>
<td>Occupational alcohol poisoning.</td>
<td></td>
</tr>
<tr>
<td>ammonia</td>
<td>Poisoning due to ammonia, its preparations or compounds, and their sequelae.</td>
<td>Any process involving manipulation of ammonia, its preparations or compounds.</td>
</tr>
<tr>
<td>ankylostomias</td>
<td>Ophthalmia due to ammonia.</td>
<td></td>
</tr>
<tr>
<td>anthrax</td>
<td>Antrhax infection.</td>
<td>Work in mines.</td>
</tr>
<tr>
<td></td>
<td>Antrhax infection.</td>
<td>Manipulation of animal substances likely to convey the anthrax virus.</td>
</tr>
<tr>
<td></td>
<td>Anthrax.</td>
<td>Manipulation of wool, animal hair, hides and skins.</td>
</tr>
<tr>
<td></td>
<td>Anthrax.</td>
<td></td>
</tr>
<tr>
<td>antimony</td>
<td>Poisoning due to antimony, its preparations and compounds, and their sequelae.</td>
<td>Use of or contact with antimony, its preparations and compounds.</td>
</tr>
<tr>
<td></td>
<td>Antimony.</td>
<td></td>
</tr>
</tbody>
</table>

* The countries marked with an asterisk are those which have ratified the 1925 Convention.

1 See also below, "Hydrocarbides".

2 In the State of Victoria, the list contains in addition the following words: "All operations involving the handling of meat or manufacture of alimentary animal products or of animal by-products connected with the occupation of butcher or slaughterhouse worker.

3 In Italy this disease is not to be found in the list of occupational diseases since it is considered as an accident.
<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>Diseases caused by arsenic and its compounds.</td>
<td>All establishments where the insured workers are habitually exposed to the action of arsenic and its compounds.</td>
<td>Ger.</td>
</tr>
<tr>
<td>Poisoning by arsenic.</td>
<td></td>
<td></td>
<td>Tasm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Finl., Swed., Switz. illin.</td>
</tr>
<tr>
<td>Arthritis</td>
<td>Diseases due to occupation.</td>
<td></td>
<td>Japan.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chile.</td>
</tr>
<tr>
<td>Barium</td>
<td>Diseases caused by benzine and its homologues.</td>
<td>All establishments where insured workers are habitually exposed to benzine and its derivatives.</td>
<td>Ger.</td>
</tr>
<tr>
<td></td>
<td>Poisoning by benzine and its homologues or its sequelae.</td>
<td>Manipulation of benzine or one of its homologues and all processes of manufacture or processes involving its use.</td>
<td>Gr. Brit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Canada (Ontl.).</td>
</tr>
<tr>
<td></td>
<td>Poisoning by benzine.</td>
<td></td>
<td>Finl.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Switz.</td>
</tr>
<tr>
<td>Barium and its homologues</td>
<td>Diseases caused by the nitro- and amido-derivatives of the aromatic series.</td>
<td>All establishments where the insured workers are habitually exposed to nitro-amido-derivatives of the aromatic series.</td>
<td>Gt.</td>
</tr>
<tr>
<td></td>
<td>Poisoning due to the use of the nitro- and amido-derivatives of benzine and their homologues (trinitrotoluene, aniline and others) or their sequelae.</td>
<td>Manipulation of all nitrated or amido-derivatives of benzine or any of its homologues, or all processes of manufacture or processes involving the use of any of these.</td>
<td>Canada (Brit. Col.), Gt. Brit., Minn., N. York, Ohio, Porto Rico.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Venez.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Switz.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Finl.</td>
</tr>
<tr>
<td></td>
<td>Poisoning by benzine and the nitro- and amido-derivatives of benzine (aniline, etc.).</td>
<td>All industrial processes involving the use of benzine or any nitro- or amido-derivative of benzine or its preparations or compounds.</td>
<td>Canada (Alb.), Queensl. S. Austrl.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aust.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>N. Jersey, Norway.</td>
</tr>
</tbody>
</table>

1 The list for the State of New York contains the additional words "hydro-derivatives of benzine".
TABLE II. — LIST OF OCCUPATIONAL DISEASES (continued)

<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Poisoning by benzene and its homologues, the nitrated and chlorinated derivatives of benzene and their homologues with the direct sequelae of these forms of poisoning.</td>
<td>—</td>
<td>Production of benzene, its homologues and nitrated and chlorinated derivatives and their homologues.</td>
<td>Ital.</td>
</tr>
<tr>
<td>Gastro-intestinal troubles due to benzene accompanied by recurrent vomiting.</td>
<td>—</td>
<td>Operations in which India-rubber in a benzine solution is used. Manufature of perfumes and soaps involving the use of benzene derivatives.</td>
<td>Switz. 1</td>
</tr>
<tr>
<td>Polynuertis of the lower limbs due to benzene.</td>
<td>—</td>
<td>Nitratcd and nitro-chlorinated compounds of benzene and its homologues. Production of benzol by distillation of coal and tar and utilisation of same.</td>
<td>France.</td>
</tr>
<tr>
<td>Haemorrhagic purpura.</td>
<td>—</td>
<td>Rectification of benzene (the chemical symbol C₆H₅). Extraction of fatty substances, extracting fat from bones, geese skin, manufacture of pigments, dyeing, dry-cleaning, manufacture and repair of pneumatic tyres, preparation of feathers, manufacture of cloth, garments, shoes and hats made of rubber, with the aid of benzine. From all the above-mentioned processes are to be excluded those operations effected inside tightly-closed apparatus with the result that no odour of benzine is perceptible.</td>
<td></td>
</tr>
<tr>
<td>Progressive anaemia with leucopenia and monocytosis.</td>
<td>—</td>
<td>Any operation involving the use of gaseous carbonic acid. Any industrial process involving the manufacture or liberation of carbonic acid.</td>
<td>Cna. (N. Bruns.)</td>
</tr>
<tr>
<td>Acute crises due to benzene (coma, convulsions).</td>
<td>—</td>
<td>All processes involving the use of carbon disulphide, its preparations or compounds.</td>
<td>Ohio, Porto Rico.</td>
</tr>
<tr>
<td>Beri-beri.</td>
<td>—</td>
<td>All establishments where injured workers are habitually exposed to the action of carbon disulphide.</td>
<td>Canada (N. Bruns.).</td>
</tr>
<tr>
<td>Bones and muscles</td>
<td>—</td>
<td>Manufacture of carbon disulphide. Extraction of oils, fats, spirits or resins by means of carbon disulphide. Production of viscose and subsequent operations preceding the spinning in factories of artificial silk.</td>
<td>Ital.</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gaseous carbonic acid.</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poisoning due to the use of carbonic acid.</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon disulphide</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poisoning due to the use of carbon disulphide or diseases consequent on such poisoning.</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diseases due to carbon disulphide.</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poisoning by carbon disulphide, together with the direct sequelae of this poisoning.</td>
<td>—</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 The following substances mentioned in the Swiss list come within this group: phenic acid, picric acid, benzidine, phenylhydroxylamine, nitroso-aniline, nitrosodimethylamine, nitroso-diethylamine, nitrosophenol, benzine oxychloride, phenylhydrazine, toluidine sulphone-chloride, toluidine.
### TABLE II. — LIST OF OCCUPATIONAL DISEASES (continued)

<table>
<thead>
<tr>
<th>Causes of Injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>Cataract</td>
<td>Carbon disulphide.</td>
<td>Chile.</td>
</tr>
<tr>
<td></td>
<td>Cataract, conjunctivitis.</td>
<td>Processes of glass manufacture in the course of which the workers are exposed to glare from molten glass (without specifying the process).</td>
<td>Gr. Brit., Minn., N. York., Venez.</td>
</tr>
<tr>
<td></td>
<td>Diseases caused by gases and fumes from spirits or resins.</td>
<td>Processes normally involving exposure of this nature during the manufacture of iron and steel.</td>
<td>Gr. Brit.</td>
</tr>
</tbody>
</table>

1 The words "diseases consequent on", etc., have been deleted.
2 and 3 The words "and their sequelae" have been deleted.
<table>
<thead>
<tr>
<th>Causes of Injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Copper</td>
<td>Copper poisoning.</td>
<td>Copper.</td>
<td>Arg.</td>
</tr>
<tr>
<td></td>
<td>Copper pruritis.</td>
<td>Bronze.</td>
<td>Braz., Chile.</td>
</tr>
<tr>
<td>Cramp</td>
<td>Telegraphists' cramp.</td>
<td>Use of telegraphic instruments.</td>
<td>Chile.</td>
</tr>
<tr>
<td></td>
<td>Occupational spasm and cramp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spasm and cramp, due to work.</td>
<td></td>
<td>W. Austri.</td>
</tr>
<tr>
<td></td>
<td>Co-ordinated occupational neuroses (strain of muscle groups).</td>
<td></td>
<td>Japan.</td>
</tr>
<tr>
<td></td>
<td>Writers' cramp.</td>
<td></td>
<td>U.S.S.R.</td>
</tr>
<tr>
<td></td>
<td>Cotton or wool twisters' cramp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyanogen and its compounds</td>
<td>Poisoning by cyanogen compounds.</td>
<td>Any operation in which compounds of cyanogen are used.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dermatitis due to cyanides.</td>
<td>Manipulation of cyanides or processes involving utilisation of cyanides.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyanogen and its compounds.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyanogen and its compounds, cyanide and calcium cyanamide.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poisoning by hydrocyanic acid and its derivatives.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dinitrophenol</td>
<td>Poisoning by dinitrophenol or sequelae of such poisoning.</td>
<td>Manipulation of dinitrophenol and processes of manufacture or processes involving use of dinitrophenol.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dinitrophenol.</td>
<td></td>
</tr>
<tr>
<td>Diseases</td>
<td>Diseases consequent on an accident or traumatism.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diseases arising from occupation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dusts, etc.</td>
<td>Diseases caused by inhalation of dusts, gases and fumes.</td>
<td>All processes or operations enumerated under the headings &quot;lead&quot; and &quot;toxic products&quot; involving the liberation of injurious dusts.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pulmonary tuberculosis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Siderosis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tobacco poisoning.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pneumoconiosis.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anthracosis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pulmonary sclerosis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Silicosis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fibrosis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asbestosis.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 In Argentina, tobacco poisoning is designated as "pulmonary".
2 In the case of Brazil, the forms of disease in question are types of pneumonia caused by dusts and the handling of tobacco.
<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Serious pulmonary diseases due to dust (silicosis).</td>
<td>Extraction and stoneware industry.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In cases where there occurs simultaneously serious</td>
<td>Metal grinding.</td>
<td>Ger.</td>
</tr>
<tr>
<td></td>
<td>pulmonary tuberculosis, the latter is dealt with for</td>
<td>China industry.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>purposes of compensation as if it were pneumo-</td>
<td>Mining industry.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>coniosis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diseases of the lower respiratory passages of the</td>
<td>Thomas slag mills,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lungs caused by Thomas slag.</td>
<td>Mixing of artificial man-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Schneeberg lung disease.</td>
<td>ures.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baker's phthisis.</td>
<td>Transport of Thomas slag.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Miller's phthisis.</td>
<td>Mining industry in the Schneeberg district.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Baking industry.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flour milling industry.</td>
<td>Ger.</td>
</tr>
<tr>
<td>Electroplating</td>
<td>Chronic skin diseases and chronic recurrent skin</td>
<td>occupations and trades entitling the workers to accident insurance.</td>
<td>U.S.S.R.</td>
</tr>
<tr>
<td></td>
<td>diseases due to electroplating processes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat foot</td>
<td>Flat foot, baker's sore leg, etc. (fatigue of the joints).</td>
<td>Workers engaged in loading, weaving, commissionaires,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>dentists, salesmen.</td>
<td></td>
</tr>
<tr>
<td>Fluor</td>
<td>Corrosion and ulceration due to flour and its derivatives.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frostbite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas fumes and smoke</td>
<td>Inhalation of gas and smoke.</td>
<td>Gas and smoke in mines or any other gases.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Liberation of asphyxiating or injurious fumes.</td>
<td>Greece.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>glanders, handling of dead animals of this class, victims of glanders.</td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td>Glanders.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hernia</td>
<td>Hernia due to occupation.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 As regards compensation for silicosis, simple or complicated by tuberculosis, in English-speaking countries legislation has developed by several stages, whilst at the outset (1900) it was excluded from the general law on accident compensation in Great Britain. It now figures in a more or less explicit form in all the laws of English-speaking countries. South Africa was called on to combat the disease in an acute form as affecting a single industry (gold mines) and adopted a system of compensation in 1912 which has not ceased to be amended and improved as regards application since that date.

Great Britain adopted the South African procedure in 1918 in regard to the refractory industries and extended it in 1927 to include metal grinding establishments. In 1928, however, the "Various Industries (Silicosis) Scheme" was drawn up (only allowing compensation for total incapacity and death) applying to risks connected with dusts generated by manipulation of quartz, quartzite, granite, sandstone gristone, and chert, excluding ore containing less than 50 per cent. free silica. Finally, other schemes have been drawn up for the pottery industry and the granite industry (compensation for partial incapacity with suspension of work). The law of 1 August 1939 also accords compensation for asbestosis. In Sweden compensation in accordance with the Act of 1930.

New South Wales in 1920 adopted a law compensating silicosis in the case of workers in the Cumberland district, and a special law for the Broken Hill Mines. Amongst the other Australian States Queensland is the only one which possesses a law granting compensation for silicosis. Western Australia passed a silicosis compensation law in 1929 which has not yet come into force.

In Canada, the Province of Alberta granted compensation for miners' phthisis (1925) and Ontario for silicosis (1926 and 1930). The other countries do not mention silicosis directly as a disease entitling the worker to compensation. However the insurance laws in certain of the United States are so drafted that silicosis may be interpreted as coming under the regulations on compensation.
### TABLE II. — LIST OF OCCUPATIONAL DISEASES (continued)

<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Respiratory, gastro-intestinal, nervous or ocular troubles due to contact with petrol products and their fumes.</td>
<td>Petrol. Any processes involving the use or direct contact with petrol and its products or their fumes.</td>
<td>Braz., Chile.</td>
</tr>
<tr>
<td></td>
<td>Poisoning by benzol spirit, naphtha or all other volatile products of petrol.</td>
<td>Petrol benzene. All industrial processes involving the utilisation of spirit, benzol, naphtha or all other volatile petrol products.</td>
<td>Finl.</td>
</tr>
<tr>
<td></td>
<td>Intoxication due to the use of formic aldehyde and sequelae.</td>
<td>All processes involving the use of formaldehyde and its preparations and compounds.</td>
<td>N. York.</td>
</tr>
<tr>
<td></td>
<td>Poisoning by methyl alcohol.</td>
<td>Formic aldehyde. All processes involving the use of methyl alcohol and preparations containing it.</td>
<td>Finl., Switz.</td>
</tr>
<tr>
<td></td>
<td>Poisoning due to methyl alcohol.</td>
<td>All processes involving the use of any substance used as a solvent or with an acetate of cellulose solvent or sequelae of such poisoning.</td>
<td>N. York.</td>
</tr>
<tr>
<td></td>
<td>Intoxication due to the use of varnishes, that is to say, poisoning by tetra-chloromethane or all substances used as solvents or with an acetate of cellulose solvent or sequelae of such poisoning.</td>
<td>—</td>
<td>Yenez.</td>
</tr>
<tr>
<td>Infections</td>
<td>Infectious diseases.</td>
<td>—</td>
<td>Chile.</td>
</tr>
<tr>
<td></td>
<td>Idem.</td>
<td>—</td>
<td>Ger.</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>Latv.</td>
</tr>
<tr>
<td>Epidemic and tropical diseases</td>
<td>—</td>
<td>—</td>
<td>Ger.</td>
</tr>
<tr>
<td>Tropical diseases, exanthematosus typhus, scarlatina, cholera, plague, yellow fever, beri-beri.</td>
<td>—</td>
<td>Yugosl.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>W. Austri.</td>
</tr>
<tr>
<td>Infectious diseases.</td>
<td>—</td>
<td>—</td>
<td>Aust.</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>Hung.</td>
</tr>
<tr>
<td>Infections</td>
<td>—</td>
<td>—</td>
<td>Japan.</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>Canada. (N. Bruns.)</td>
</tr>
<tr>
<td>Erysipelas</td>
<td>—</td>
<td>—</td>
<td>Queensl.</td>
</tr>
<tr>
<td>Plague</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Smallpox</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Infections due to the handling of sugar.</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Asiatic cholera, bubonic plague, diphtheria, measles, mumps, scarlet fever, smallpox, tetanus, typhoid fever or other infectious diseases.</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>

1 In the N. Jersey list the occupations are not enumerated.
## TABLE II. — LIST OF OCCUPATIONAL DISEASES (continued)

<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td></td>
<td>(3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All work involving handling of meat, manufacture of products made from meat, manufacture of animal products, combing and sorting of wool, handling of hides and skins, wool, hair, or animal carcasses.</td>
<td>Queensl., Victoria 1.</td>
</tr>
<tr>
<td>Tetanus.</td>
<td></td>
<td>--</td>
<td>Chile.</td>
</tr>
<tr>
<td>Actinomycosis.</td>
<td></td>
<td>--</td>
<td>Idem.</td>
</tr>
<tr>
<td>Anthrax.</td>
<td></td>
<td>Mining processes.</td>
<td></td>
</tr>
<tr>
<td>Inflammation</td>
<td>Sub-cutaneous cellulitis of the hand.</td>
<td>--</td>
<td>Canada (Alb. 2 and Br. Col., Nov. Scot.), Chile, Gt. Brit., Minn., Queensl. 4, Venez., W. Austri. 5.</td>
</tr>
<tr>
<td></td>
<td>Sub-cutaneous cellulitis or acute bursitis of the knee.</td>
<td>--</td>
<td>Canada (Brit. Col., Nov. Scot.), Chile, Gt. Brit., Minn., Queensl. 4, Venez., Victoria, W. Austri. 5.</td>
</tr>
<tr>
<td></td>
<td>Sub-cutaneous cellulitis or acute bursitis of the elbow.</td>
<td>--</td>
<td>Canada (Brit. Col., Nov. Scot.), Chile, Gt. Brit., Minn., Queensl. 4, Venez., Victoria, W. Austri. 5.</td>
</tr>
<tr>
<td>Tenosynovitis and pre-patellar bursitis. Primary tenosynovitis characterised by passive effusion or crepitation in the tendon sheaths of the flexor or extensor muscles of the hand.</td>
<td>Frequently repeated movements or vibrations or continuous pressure.</td>
<td>Ohio.</td>
<td></td>
</tr>
<tr>
<td>Inflammation of the synovial sheaths of the wrist joint.</td>
<td>Mining operations.</td>
<td>Chile, Gt. Brit., Queensl. 4, Venez., W. Austri. 5.</td>
<td></td>
</tr>
<tr>
<td>Inflammation of the tendon sheaths due to occupation.</td>
<td></td>
<td></td>
<td>Japan.</td>
</tr>
<tr>
<td>Bursitis or synovitis.</td>
<td></td>
<td>All processes involved in mining work.</td>
<td>N. York.</td>
</tr>
<tr>
<td>Miners' diseases including only forms of inflammation of the sub-cutaneous cellular tissue, forms of bursitis, ankylostomiasis, of tenosynovitis and of nystagmus.</td>
<td>Stone workers, slaters, bridgebuilders, miners</td>
<td>U.S.S.R.</td>
<td></td>
</tr>
<tr>
<td>Chronic synovial inflammation of the knee and elbow.</td>
<td></td>
<td>Washermen, ironers, workers engaged in tying parcels.</td>
<td>U.S.S.R.</td>
</tr>
<tr>
<td>Itch</td>
<td></td>
<td>Singers, teachers.</td>
<td></td>
</tr>
<tr>
<td>Miners' itch.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laryngitis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of voice as a result of lesions of the vocal cords. Chronic laryngitis, knot on the vocal cords (singers, due to strain of the vocal cords).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 The Victoria list merely contains: manipulation of meat or animal products. This list, on the other hand, bears the words "septicaemia or its sequelae".
2 The Alberta list contains, besides mining operations, the words "or other industries demanding continuous use of tools".
3 Industries comprised in the list are: mines, quarries, crushing and cutting of stone.
4 In Great Britain the law contains the additional words "and in the region of the knee".
### TABLE II. — LIST OF OCCUPATIONAL DISEASES (continued)

<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Lead</td>
<td>Poisoning by lead, its alloys and compounds with direct sequelae of this poisoning.</td>
<td>International list.</td>
<td>Aust., Belg., Bul. Ger.</td>
</tr>
<tr>
<td>Diseases caused by lead and its compounds.</td>
<td></td>
<td></td>
<td>Fr., I., Bulg., CUBA, Finl., Hong.</td>
</tr>
<tr>
<td>Poisoning due to lead or its compounds.</td>
<td></td>
<td></td>
<td>I.F.S., Ital., Japan, Luxemb.</td>
</tr>
<tr>
<td>Paralysis of the extensor muscles and other forms of lead paralysis.</td>
<td></td>
<td></td>
<td>S.W. Afri-cal, Victoria, W. Austri.</td>
</tr>
<tr>
<td>Nephritis.</td>
<td></td>
<td></td>
<td>Arg., Bol., Braz.</td>
</tr>
<tr>
<td>Cardial vascular symptoms due to lead.</td>
<td></td>
<td></td>
<td>Chile, F.M.S., New Jersey, N. Zealand, Venez.</td>
</tr>
<tr>
<td>Lead gout.</td>
<td></td>
<td></td>
<td>Tasm.</td>
</tr>
<tr>
<td>Anaemia due to zinc.</td>
<td></td>
<td></td>
<td>Ilin.</td>
</tr>
<tr>
<td>Forms of meningitis-encephalitis due to lead.</td>
<td></td>
<td></td>
<td>France.</td>
</tr>
<tr>
<td>Amaurosis due to lead.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All establishments where insured workers are habitually exposed to the action of lead and its compounds.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manipulation of lead, its preparations and compounds.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mines and allied industries.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead foundries. All processes or work involving manipulation of acetate of lead, white lead, or lead chromate, litharge, minium and lead arsenate.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metallurgy and refining of lead.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead foundry work, rolling of lead and its alloys.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead and zinc foundry work.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treatment of ores containing lead including lead shot from zinc factories.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Lead hardening and lead refining.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Type foundling with lead alloys.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manufacture and polishing of tinware with lead alloys.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Soldering by means of lead alloys.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soldering operations on metallic objects by means of lead or lead-bearing agents.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Working composing machines utilising lead alloys.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Manufacture of toys with lead alloys.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manufacture of metallic caps and lids containing lead.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Removing of solder from old preserve boxes and other objects soldered by means of lead alloys.</td>
<td></td>
</tr>
</tbody>
</table>

1 In Belgium the printing industries are not included on the list, which contains on the contrary: manufacture of zinc, rolling of lead, extraction of silver or argentiferous lead, manipulation of articles made of lead or plumbiferous alloys and all other operations liable to liberate plumbiferous fumes or dusts.
### Compensation — 443 — Occupational Diseases

**Table II. — List of Occupational Diseases (continued)**

<table>
<thead>
<tr>
<th>Causes of Injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
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<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>Tinning with an alloy containing lead.</td>
<td></td>
<td>France.</td>
</tr>
<tr>
<td></td>
<td>Manipulation of type made with lead alloys.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manipulation or use of printing inks containing lead.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacture of lead compounds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crystal factories (preparation and handling of lead-bearing compounds in these factories).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacture and grinding of colours with a lead basis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Painting operations and other operations involving the use of lead-bearing substances or applied to lead-bearing substances.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blow-pipe work on objects covered with lead-bearing paint.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacture and repair of lead storage batteries.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacture of drying oils and varnishes with lead content.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacture of lead enamels and their application.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacture of pottery and china with lead enamel.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decoration of porcelain by means of enamels with a lead content.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enamelling of metals by means of lead-bearing preparations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Varnishing and coating with lead-bearing products.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use of colours or substances containing lead during dyeing operations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacture of artificial flowers with lead colours. Polishing by means of lead filings or lead putty.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>Diseases due to action of manganese compounds.</td>
<td>Trades and occupations subject to compulsory insurance.</td>
<td>Ger.</td>
</tr>
<tr>
<td></td>
<td>Poisoning due to the use of manganese.</td>
<td>Manipulation of manganese or substances containing manganese (dusts).</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>Poisoning by mercury, its amalgams and compounds, with the direct sequelae of such poisoning.</td>
<td>International list.</td>
<td>Switz.</td>
</tr>
</tbody>
</table>

1 The Ohio law refers to "bi-oxyde of manganese".
2 The Belgian law contains the additional words: "manipulation of mercury and its amalgams".
3 The Italian law contains in addition the words: "mercury silvering of mirrors".
<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Diseases due to mercury and its compounds.</td>
<td>Poisoning caused by the use of mercury or diseases consequent on such poisoning.</td>
<td>All establishments where insured workers are habitually exposed to the action of mercury and its compounds.</td>
<td>Ger. *</td>
</tr>
<tr>
<td>Nephritis due to mercury.</td>
<td>-</td>
<td>-</td>
<td>Argent., Bol., Braz., Chile, F.M.S., New Jersey, N. Zealand, Venez.</td>
</tr>
<tr>
<td>Muscles</td>
<td>Muscular contractions</td>
<td>See &quot;Bones&quot;, &quot;Muscular Contractions&quot;.</td>
<td>Swed. *</td>
</tr>
<tr>
<td>Myopia</td>
<td>Advanced myopia (ocular fatigue due to close work).</td>
<td>Engine-drivers, locksmiths, postal operators (stamping machines).</td>
<td>U.S.S.R.</td>
</tr>
<tr>
<td>Nephritis Nerves (diseases of)</td>
<td>Nephritis. Neuroglas and neurites of the extremities (fatigue of or pressure on nervous centres). See also &quot;Cramp&quot;.</td>
<td>Dressmakers, watchmakers, engravers, type correctors.</td>
<td>U.S.S.R.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bol.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>U.S.S.R.</td>
</tr>
<tr>
<td>Causes of Injury and certain effects</td>
<td>Diseases or affections in accordance with the national law</td>
<td>Occupations or substances mentioned in the national lists</td>
<td>Country</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>----------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Nystagmus</td>
<td>Deafness caused by noise, or hardness of hearing</td>
<td>Nitre, nitrous fumes, nitrous gas, nitric acid.</td>
<td>Venez.</td>
</tr>
<tr>
<td></td>
<td>Diminution of hearing consequent on lesions of the</td>
<td>Nitrous gas, oxide of nitre, nitric acid.</td>
<td>Switz.</td>
</tr>
<tr>
<td></td>
<td>internal ear.</td>
<td></td>
<td>Finl.</td>
</tr>
<tr>
<td></td>
<td>Affection designated by the name of miner's nystagmus</td>
<td>Metallurgical industry.</td>
<td>Ger.</td>
</tr>
<tr>
<td></td>
<td>which occurs amongst miners and other workers whether</td>
<td>Weavers, coppersmiths and nail manufacturers.</td>
<td>U.S.S.R.</td>
</tr>
<tr>
<td></td>
<td>accompanied or not by the symptom of trembling of the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>eyes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupational poisoning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Occupational poisons.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Forms of poisoning.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Diseases due to phosphorus.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poisoning due to the use of phosphorus or sequelae of</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>such poisoning.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poisoning by phosphorus (phosphorism).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poisoning by white or yellow phosphorus and the direct</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>sequelae of such poisoning.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poisoning by phosphorus and phosphoric mixtures.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poisoning by phosphorus and its compounds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poisoning by phosphorus so far as such forms of</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>poisoning may be attributed to the manipulation of</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>phosphorus in course of occupation.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
### Table II. — List of Occupational Diseases (continued)

<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Pitch, Tar, bitumen, mineral oil, paraffin, Soot, etc.</td>
<td>Phosphoric necroses.</td>
<td>Manufacture of strips of phosphorus paste for lighting miners' lamps.</td>
<td>France.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manufacture of detonating toys involving the use of white phosphorus.</td>
<td>Switz.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yellow phosphorus and its combinations, phosphoretetted hydrogen.</td>
<td>Swed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phosphorus and its compounds.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Epitheliomatous cancer or cutaneous ulcer caused by pitch, tar, bitumen, mineral oil or paraffin or compound product or residue of one of these substances.</td>
<td>Manipulation or use of pitch, tar, bitumen, mineral oil, or paraffin or a compound product or residue of one of these substances.</td>
<td>Ger.</td>
</tr>
<tr>
<td></td>
<td>Chronic and chronic recurrent diseases of the skin due to the action of soot, paraffin, tar, anthracene, pitch and analogous products.</td>
<td>Occupations and processes subject to accident insurance.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Epitheliomatous cancer or ulceration of the skin or of the cornea caused by mineral oils, pitch, tar or tar compounds.</td>
<td>Manipulation of mineral oils, pitch, tar or tar compounds.</td>
<td>Minn. 1, N. York 2, Ohio 3, Porto Rico 4, Queensl., Venez., W. Austri.</td>
</tr>
<tr>
<td></td>
<td>Epitheliomatous cancer of the scrotum (chimney sweeps' cancer).</td>
<td>Chimney sweeping</td>
<td>Ger.</td>
</tr>
<tr>
<td></td>
<td>Cancer of the skin manipulation of pitch, tar, paraffin, anthracene and analogous substances)</td>
<td>Soot, tar, pitch, anthracene and similar substances.</td>
<td>Aust.</td>
</tr>
<tr>
<td></td>
<td>Ulceration of the cornea due to the use of pitch, tar, bitumen, mineral oil or paraffin or a compound product or residue of one of these substances.</td>
<td>Coal tar and wood tar.</td>
<td>Finl.</td>
</tr>
<tr>
<td></td>
<td>Corrosions or ulcerations caused by tar.</td>
<td>Tar, its fumes and its oils.</td>
<td>Switz.</td>
</tr>
<tr>
<td>Pneumatic hammers</td>
<td>Diseases of the muscles, the bones and joints due to manipulation of compressed air tools.</td>
<td>Occupations and processes subject to accident insurance.</td>
<td>U.S.S.R.</td>
</tr>
<tr>
<td>Poisoning</td>
<td>(See &quot;Occupational Poisoning&quot;).</td>
<td></td>
<td>Ger.</td>
</tr>
<tr>
<td>Radiant heat</td>
<td>Conjunctivitis or other affections of the eyes due to the manipulation of substances of high temperature.</td>
<td></td>
<td>Japan.</td>
</tr>
<tr>
<td></td>
<td>Dermatitis and eye diseases.</td>
<td></td>
<td>Swed.</td>
</tr>
<tr>
<td></td>
<td>Inflammation of the retina.</td>
<td>Glass-blowers.</td>
<td>U.S.S.R.</td>
</tr>
</tbody>
</table>

1 The Minnesota list contains in addition bitumen and paraffin and refers to "compounds, products or residues" of the substances in question.
2 The list is exactly similar to that of Minnesota.
3 The Ohio list comprises: carbon, pitch, tar or tar compounds.
4 In the Porto Rico list "epitheliomatous cancer" is omitted.
<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation and radioactive substances</td>
<td>Inflammation, ulceration and malignant lesions of the skin and the subcutaneous tissues due to exposure to X-rays or to radioactive substances.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Poisoning due to radium.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Diseases due to X-rays or other sources of radiant energy (radium, mesothorium).</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>X-rays.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Necroses due to radium.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Necroses due to mesothorium.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Grave affections of the tissues (dermatites, ulceration, malignant tumours and forms of atrophy)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Radiologists' cancer. Period of liability: five years.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Simple anaemia with leucopenia due to the influence of rays. Period of liability: one year.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Pernicious anaemia due to the influence of rays. Period of liability: one year.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Leukaemia due to the influence of rays. Period of liability: one year.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Radionecrosis of the bones due to the influence of rays. Period of liability: one year.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Scurvy</td>
<td>Scurvy.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Silver</td>
<td>Silver.</td>
<td>—</td>
</tr>
<tr>
<td>Skin substances harmful to: (a) Dusts and liquids</td>
<td>Dermatites caused by dusts or liquids: (a) Ulceration of the skin due to dusts or liquids.</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

1 In the list for Western Australia the two paragraphs (a) and (b) form one; the ulcerations corresponding to paragraph (a) are designated "eczematous".
### TABLE II. — LIST OF OCCUPATIONAL DISEASES (continued)

<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>(b) Oils and lubricants, etc.</td>
<td>(b) Ulceration of the mucous membrane of the nose or of the mouth due to dusts.</td>
<td>—</td>
<td>Japan.</td>
</tr>
<tr>
<td></td>
<td>Dermatitis of the fingers due to the manipulation of crude silk.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grinders' eczema.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eczema affecting workers handling tar, cement and hydrocyanic acid derivatives.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ulceration of the skin and mucous membrane of the nose and mouth due to working with irritant and caustic substances.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chronic inflammation of the skin (handling of irritant and caustic products).</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Dermatitis venera.</em></td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dermatitis caused by work in acid mineral water.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dermatitis.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vesications and abrasions of the skin.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>(c) Various causes</td>
<td>Infection or inflammation of the skin or contact surfaces due to oils, cutting oils or lubricants, dusts, liquids, smoke, gas or fumes.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corrosions or ulcerations.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chronic and recurrent diseases of the skin due to electric plating processes and handling of exotic timber.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Solvents</td>
<td>Poisoning due to the use of varnishes (aircraft). that is to say, poisoning by any substance used as a solvent of acetate of cellulose or with a solvent of this type, or sequelae of such poisoning.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Sulphur</td>
<td>Poisoning by sulphur or sequelae of such poisoning.</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Sulphuretted hydrogen</td>
<td>Diseases due to sulphuretted hydrogen.</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- **(1)** Causes of Injury and certain effects.
- **(2)** Diseases or affections in accordance with the national law.
- **(3)** Occupations or substances mentioned in the national lists.
- **(4)** Country.
<table>
<thead>
<tr>
<th>Causes of injury and certain effects</th>
<th>Diseases or affections in accordance with the national law</th>
<th>Occupations or substances mentioned in the national lists</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Tin</td>
<td></td>
<td>Tin.</td>
<td>Chile.</td>
</tr>
<tr>
<td>Tobacco poisoning (Occupational)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>See also “Dusts”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethane</td>
<td>Poisoning due to the use of tetrachloroethane or sequelae of such poisoning.</td>
<td>Jaundice, cirrhosis, polyneuritis caused by tetrachloroethane.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetrachloromethane</td>
<td>Poisoning by tetrachloromethane or any other substance used as a solvent of acetate cellulose.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic woods</td>
<td>Poisoning due to the use of Gongolma Kamassi (African boxwood) or sequelae of this poisoning.</td>
<td>All operations involving the use of tetrachloroethane.</td>
<td>Gr. Brit.</td>
</tr>
<tr>
<td></td>
<td>Dermatitis due to juniperus virginiana (red cedar wood).</td>
<td>Manufacture of artificial pears.</td>
<td>France.</td>
</tr>
<tr>
<td></td>
<td>Various forms of dermatitis produced by manipulation of kinds of wood such as “jabilo” and others.</td>
<td>Various operations involving the use as a solvent of tetrachloroethane.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diseases of the skin due to contact with or inhalation of blackwood dust (red pine).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asthma or asthmatic attacks due to contact with or inhalation of blackwood pine dust.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trinitrophenol</td>
<td></td>
<td>Picric acid.</td>
<td>Vinl.</td>
</tr>
<tr>
<td>Varicose veins</td>
<td>Dilatation of the veins, of the lower members, varicose veins and ulceration (prolonged walking or standing).</td>
<td>Dockers, weavers, messengers, dentists, shop assistants.</td>
<td>U.S.S.R.</td>
</tr>
<tr>
<td>Zinc and brass</td>
<td>Poisoning by the use of zinc or brass.</td>
<td>All industrial processes involving the manufacture, casting or refining of zinc or brass.</td>
<td>Ohio, Porto Rico.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zinc.</td>
<td>Chile.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brass work and zinc casting.</td>
<td>Illinois.</td>
</tr>
</tbody>
</table>
diseases, there is unfortunately a want of intelligent co-ordination, which is obviously the prerequisite of practical results of far-reaching value. Many of the investigations which have been made, under the auspices of either labour or industry, have failed to produce results satisfactory to all concerned for this reason.

A notable exception in this respect is the Health Survey of the Printing Trades, carried on under the authority of the Joint International Council, representing employers and employees. In that survey a large measure of cooperation — official, corporate or otherwise — has been secured with the most admirable results. That survey is a typical illustration of the inadequacy of former investigations to meet modern requirements, for it may be laid down as a fundamental principle of labour relations that the conditions of work must be such as not to predispose to ill-health or premature death.

The principle has been laid down in the Federal Transportation Act that in any arbitration proceedings involving wage disputes, the Board of Arbitration is required to take the hazards of the occupation, or the industry, into account. The most significant practical application of that principle is to be found in the miners’ wage dispute of 1921, when a mass of so-called evidence was introduced on behalf of the Miners’ Union attempting to prove that mining conditions were not only seriously detrimental to health and life, but steadily growing worse. It did not require a large amount of evidence to establish that the contentsions made were not based on statistical enquiries, or on recent data, but largely upon statements of an earlier date. But the case precisely illustrates the danger of drawing far-reaching conclusions from an insufficient basis of fact and information. The nature of all such material, after best, can at any given time only prove suggestive of the probable state of things. The most careful statistical enquiry cannot do more than reveal an approximate state of facts, but it is of the very first importance that no method or means should be neglected to establish the truth of a given situation, beyond the chance of serious controversy.

In the Health Survey of the Printing Trades, these considerations have not been lost sight of. Conducted by an impartial agency, competent to initiate an original enquiry, the required information was obtained from the following sources:

First, a questionnaire was sent to all

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**Industrial Sickness Statistics in the United States**

Industrial sickness, for the present purpose, may be defined as follows:

**Industrial sickness** is that form of labour impairment of a pathologic nature which can be traced to the vocational activity of the worker affected, and which disables him from the performance of his regular duties for a more or less prolonged period of time.

**Industrial mortality** is that portion of the general mortality which is traceable to the occupation followed at the time of death or previous thereto.

**Industrial efficiency** is that condition of health and strength which yields the largest measure of occupational results, without undue fatigue or bad physical effects.

The use of these terms is rapidly broadening, particularly in connection with workmen’s compensation legislation. In a more restricted sense the terms affect decisions in life and accident insurance, as well as liability legislation not covered by specific statutory requirements. In workmen’s compensation legislation, particularly in English-speaking countries, industrial diseases are as yet as a rule provided for to only a limited extent. The scheduled group of such diseases under the British Workmen’s Compensation Act of 1906, while somewhat extended during more recent years, falls still measurably below the expectations of those whose interests are directly concerned in a broader interpretation.

While there is much activity in advancing knowledge regarding industrial
of the labour organisations representing the essential branches of the printing trades. Second, a somewhat different questionnaire was sent to representative employers; it obviously would have been impossible to cover the entire field, on account of the immense extent of the printing industry and the enormous number of small printing plants, with widely varying conditions. Third, the cooperation of sanitary officers of many of the principal cities was secured, and on the basis of a small blank, inspections were made by qualified officials into the actual sanitary conditions of representative plants, large and small. Fourth, an official of the United States Bureau of Labour, with long experience in the printing trades, was commissioned to visit personally a large number of printing plants throughout the country, reporting upon the shop conditions observed on a visit personally made, based upon an extended knowledge of the situation. Fifth, supplemental to the foregoing, a considerable amount of statistical information regarding mortality was collected: (1) from general sources, such as Boards of Health, or Departments of Vital Statistics, (2) through the mortuary records of principal printers’ labour associations, (3) the experience data of life insurance companies, particularly under group insurance. Sixth, through the cooperation of the resident physicians of two printers’ tuberculosis sanatoriums medical examinations were made and much additional information secured relative to several hundred tuberculous printers, in order to reveal any facts bearing upon a possible occupational origin of the disease. This line of investigation was amplified by the cooperation of several large insurance companies, through the cooperation of non-tuberculous printers, through the cooperation of several large insurance companies, or otherwise. Seventh, through the expert special agent of the United States Bureau of Labour, during those field investigations, nearly a thousand physical measurements were secured of printers, revealing the essential bodily proportions, particularly as regards the chest and the height and age. Eighth, through the cooperation of the United States Bureau of Mines, a number of dust and fume investigations will be made, which are expected to throw much light upon the debatable question whether the air conditions in the ordinary printing shop, or the dust of machine composition, are seriously detrimental to health. Ninth, special information was secured regarding a large number of aged printers, still members of labour organisations; to all such an individual blank was sent, to secure a considerable amount of additional and highly useful information, including the duration of the trade life, the sickness experience, the present condition of health, the occurrence of lung affection, eye-strain, lead poisoning, etc. The average trade life of nearly five hundred such printers was found to be forty-nine years. Tenth, an effort was made to secure special information regarding accidents in printing plants, but most of the evidence in this respect was negative. Through the cooperation of Workmen’s Compensation Boards, or otherwise, much useful information, however, was secured, likely to prove suggestive in further efforts to reduce the accident hazards.

This, in brief, is an illustration of an industrial disease investigation, likely to provide the largest measure of practical results. The conclusions to be derived from the investigation cannot be successfully contradicted, since the evidence was impartially derived from employers and employees and governmental sources.

Industrial sickness statistics are as yet only available in a fragmentary form. The principles upon which such statistics should be collected have not been clearly defined and perhaps are not reducible to generally acceptable terms. So much sickness is of so short a duration that its compensable nature is largely a matter of personal inclination. Many men, at any given time, may be at work, although slightly indisposed. Mere records of absences from work are inconclusive, because they may, or may not, represent sickness, within the sense of the definition generally adopted.

In the Health Survey of the Printing Trades both labour organisations and employers were questioned as to the number of men at work and the number of men absent on account of sickness. On the basis of returns made by 1,489 employers, representing 65,248 employees, the number absent at the time of the enquiry, on account of sickness, was only 423, or 0.6 per cent. The corresponding returns received from 151 labour organisations, representing 35,783 members, showed that 286, or 0.8 per cent., were absent on account of sickness. Both returns are suggestive of an extraordinarily small incidence of sickness, indicative of health conditions conforming, on the whole, to reasonably exacting standards.

It would seem that such a method is more likely to produce practical
results than the experience under compulsory health insurance, or of voluntary sickness associations, which to a certain extent hold out the temptation of malingerers, which may be more or less prolonged.

The wholly unsatisfactory character of American occupational mortality and morbidity statistics is reflected in the treatment sometimes devoted to this subject.

It requires no extended analysis of certain statistical tables to reveal inherent inconsistencies, emphasising the inconclusiveness of the data and the risk of basing far-reaching conclusions upon their significance. Thus, for illustration, combining all ages, the mortality rate of male bar-tenders is given as 6.7 per thousand, while the rate for brewers and maltsters is given as 14.4. Finally, compositors and typesetters are stated to have experienced a mortality rate of 8.3 per thousand, while for confectioners the rate was only 0.8. Such apparent contradictions, obviously opposed to known facts regarding the industries referred to, are worthy of remark.

It would hardly serve a useful purpose to enlarge upon foreign data subject to interpretation on the part of those thoroughly familiar with the conditions under which they have been collected. The standard occupational mortality tables for England and Wales may, however, be referred to as the most trustworthy sources of occupational mortality conditions, while they, of course, preclude definite conclusions concerning the morbidity for particular trades. As has been pointed out, the term "sickness" has not been defined in general usage to the point of general acceptance and extreme caution is therefore, required in comparing the returns of one country with another. There is the utmost urgency of standardising the methods of occupational sickness investigations, so that a better basis of acceptable facts may be secured. It may be suggested that all sickness causing an absence from work of less than three days should be excluded from industrial sickness statistics.

The most useful source of information would seem to be trade union experience, provided such organisations can be induced to adopt statistical methods above serious criticism. Unfortunately, few such organisations have realised the extreme importance of carefully examining the facts of their experience from the medical point of view, being primarily concerned with the distribution of cash benefits to their beneficiaries. There is, however, a wealth of material susceptible of critical analysis, which should be made available to those who are directly concerned with occupational disease investigations.

A striking illustration of the foregoing is the mortality experience of the International Granite Cutters' Union, utilised in the report The Problem of Dust Phthisis in the Granite Industry, published by the United States Bureau of Labour Statistics in 1922. While that investigation was primarily concerned with mortality, there are reasons for believing that it might to advantage have also been extended into the field of morbidity.

In the course of that investigation the remarkable fact was disclosed that while tuberculosis had very considerably declined among the general population, in the stone-cutting communities the pulmonary tuberculosis death rate of granite workers had increased from 3.32 thousand during 1896-1899, to 10.44 per thousand during 1915-1918. But it requires no extended investigation to disclose the inaccuracy of many of the diagnoses of pulmonary tuberculosis, which more properly should have been certified as fibroid phthisis, often without tubercular complications.

The consistency of the trade union mortality experience, revealing a general death-rate from all causes of 20.1 per thousand among granite-cutters of the Barre, Vermont, district, is illustrated by the fact that the corresponding mortality of men in stone and slate quarries of England and Wales during 1890-1892 was 20.3 per thousand; but the mortality from so-called pulmonary tuberculosis among granite-cutters of Barre, Vermont, was 11.84 per thousand during 1911-1917; against 3.62 per thousand among the stone and slate quarry workers of England and Wales. The higher mortality from so-called pulmonary tuberculosis among the granite workers of Vermont is directly attributable to the conditions under which the work is being carried on, which involves the continuous inhalation of large quantities of highly siliceous stone dust.

The granite stone investigation further emphasises the supreme importance of the trade life, in determining
the incidence of particular affections. It was pointed out at the time by Dr. Hoffman that the results suggested the need of a thorough and impartial medical enquiry into the facts conforming to the methods followed by the Miner's Phthisis Prevention Office of South Africa, in view of the conclusion that "the health injuries or consequences of dust exposure in granite-cutting and quartz-mining -- under normal conditions, do not attain the most serious proportions until a workman has been employed at his trade for about twenty-one years".

The Vermont investigation also emphasises the importance of taking into consideration the physique of the workers concerned. From such data as were collected by means of physical examinations, it was stated that the physique of granite workers was normally above the average for occupied males generally, in accordance with life insurance experience, and that, therefore, a physically superior type suffered disastrously as the result of occupational conditions, more or less admitting of remedial measures.

The foregoing illustration must be sufficient for the present purpose, of emphasising the value of a broader method of enquiry into occupational conditions, productive of disease or premature death. It admits of no argument that the problem is an enormous one, particularly in the United States, where the number of persons employed in gainful occupations at the present time is placed at nearly forty-two millions, or 39.4 per cent. of the total population.

There is small inherent value in occupational mortality and morbidity statistics for industries collectively considered, for the effects of injurious conditions invariably fall upon a relatively small proportion of the workers engaged in particularly hazardous occupations. The segregation of such employments is, therefore, of the very first importance, if practical results are to be realised. Thus, for illustration, in the pottery industry, only a relatively small number of workmen are exposed to the actual hazard of lead poisoning, and the same is unquestionably true of printing and the manufacture of electric batteries. If health injurious conditions are to be removed, they must, therefore, be dealt with in a highly specialised manner, as best illustrated by some of the extremely valuable reports on particular occupations, which have been forthcoming from the British Factory Inspection Department. The field which requires thorough investigation is enormous. Many enquiries demand highly specialised, technical training, if the results are to be acceptable to both employer and employee. No advantage is gained by merely pointing out health injurious conditions, unless the cause or conditioning circumstances are emphasised with practical suggestions for their removal or control. It has been shown by the phosphorus match legislation that the statutory prohibition of dangerous processes may result in the radical improvement of conditions heretofore unbelievably dangerous or otherwise bad.

In conclusion attention may be directed to an effort made by the United States Public Health Service to improve the sickness statistics for industrial and other establishments. That office has published a number of important papers, of which a recent discussion on "Sickness among Office Workers" illustrates this principle. The information was obtained through the co-operation of the medical research department of a large corporation in the Middle West.

The average number of persons on the office pay-roll during the year ending 31 January 1921 was 1,289, with women in the majority. A record was kept of the hours lost from work by each person, on account of sickness and injuries and the data obtained were checked through the medical department. The illnesses causing disability were diagnosed through the medical department or with the aid of the family physician, and an attempt was made to include every hour lost from work on this account.

During the year under observation there were 11,259 calls at the dispensary representing 2,751 lost-time cases. The number of eight-hour days absent from work, on account of such sicknesses was 10,450, representing an average of 8.15 days of eight hours each. The most important cause of absences was common colds, represented by 435 cases and 1,393 visits, but the average number of days lost on account of such colds was only 0.50. Another important cause of absences was sore throat, represented by 53 cases, 1,014 calls at the dispensary and an average absence of 0.23 days. Minor injuries come next, represented by 52 cases and 1,153 visits, but the average number of days lost on account of such colds was only 0.06. Influenza caused 403 cases of illness and 2,520 days' absence, representing an average time loss of 1.97. Other illnesses are of minor importance.

It is obvious that such an experience is not representative for industrial workers, but it is suggestive of the pos-
sibilities of securing better data for men and women at work in more dangerous or unhealthy occupations. It is hardly necessary to point out that to be strictly accurate and comparable all such information should be collected separately for men and women. In the case of the present investigation it is stated that 65 per cent. of the employees were women.

A more important investigation for the present purpose is a preliminary report concerning Morbidity Statistics as an Aid to Preventing Illness among Miners, by R. R. Sayers, Chief Surgeon, U.S. Bureau of Mines, as Chairman of a Sub-Committee on Preventive Illness, appointed by the American Institute of Mining and Metallurgical Engineers. The report contains the following statement:

All operators are interested in knowing how much working time is lost by the employees and how much of this absenteeism is due to sickness. Many of the larger companies, and some of the smaller ones, have the requisite organisation to determine the effect of different kinds of work and working conditions on those exposed in terms of frequency and severity of disability. Some plants now secure this data, and use it: others secure it, but make little or no use of it. One lead smelter in the United States has a full-time medical and safety organisation which makes physical examinations of all applicants for employment and at intervals thereafter. Sickness records are kept of all illness. This company decreased the yearly incidence of lead poisoning from 87 cases to 35 cases in four years. However, they had not compiled and analysed their records during the period, but on doing so found that the decrease in the number of cases was chiefly among those occurring about the blast furnace. At this point the number of cases was decreased from 47, occurring during a year, to 5 cases during a like period. The analysis of the records further showed that there had been little or no decrease in the number of cases occurring about the preroasters and charge floor — 24 cases as compared with 22 cases per year at the end of the period. A physical examination of each of the employees of the above departments was made at once by the plant physician and over 60 per cent. of the total number were found to be ledared. The conditions in the three departments were investigated and practical means taken to eliminate the hazard.

It is not feasible to reproduce the forms or blanks used in connection with the suggested investigations, but it will be sufficient for the present purpose to point out the direction in which American thought concerning the subject is gradually developing. There is now a clearer recognition of the importance of the sickness factor in industry and a better appreciation of the practical value of preventive methods. All of this, of course, implies at the same time the development of employees' medical and hospital service work, including the physical examination of employees and their periodical re-examination, as occasion may suggest.

In conclusion may be cited the following remarks by Dr. Sayers, as emphasising perhaps to best advantage the modern viewpoint of joint management, in its relation to health and longevity, now widely met with in the United States of America:

A plan is now being devised for the systematic utilisation of such morbidity records as are being accurately kept. About once in every six months a representative of the Public Health Service plans to visit those companies which are keeping sickness records, go over some of the records to see that the work is being properly carried out, help to overcome difficulties that may have arisen, and suggest an appropriate line of analysis of the data.

In return, the service expects co-operation from companies in making morbidity data available for the study of industrial hygiene and the advancement of industrial medical work. The results of some of the studies the Service will want to publish, and the assistance of different companies will be needed in the work of making the data available for the purposes suggested. A condition is considered "good" or "bad" as based on experience elsewhere, or too often on theoretical and general grounds. Groups of men are given physical examinations and placed on jobs usually upon rather general considerations, or conclusions are drawn from the presence of specific defects, as to the effect of occupation. Because of inadequate data, and at times unsuitable methods, conclusions doubtless have been reached that have been unjust to the industry, and, on the other hand, probably serious conditions have been overlooked because the right kind of methods have not been used for discovering them.

The continuous record of the occurrence of ill-health for each employee affords a sound and thoroughly practical method. It is in line with the principles of scientific research. The sickness record of an employee is a dependable measure of his health, provided that illness of short duration be recorded, even though some diagnoses be statements of symptoms only.

It seems appropriate in this connection to refer very briefly to a standard method of industrial sickness reporting, based upon investigations on the part of the United States Public Health Service. The Service recommends two plans for recording and reporting sick-
ness among industrial employees and sick benefit associations, formulated by a special committee on industrial morbidity statistics, of the Vital Statistics Section of the American Public Health Association.

Plan A provides for an individual personnel card, which is to be kept for every employee and to be taken into consideration, whether the individual becomes sick or not. The card suggested is as follows:

MODEL FORM FOR PERSONNEL AND SICKNESS CARD—FACE

<table>
<thead>
<tr>
<th>1. Name of employee.</th>
<th>2. Check No.</th>
<th>3. Date this record begins</th>
<th>4. Firm No.</th>
<th>5. Date employment ended.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


11. Departments and occupations in plant.

From— To— Months. Department. Occupation. Possible injurious conditions.

12. Former occupations outside of plant.


13. Remarks:

The card on the reverse side contains the following information:

MODEL FORM FOR PERSONNEL AND SICKNESS CARD—REVERSE SIDE

Record of Absence from Sickness and Non-Industrial Injuries

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning— End—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18. Remarks:

Form A-1-1919—U. S. Public Health Service.

When personnel cards of any other form are already kept, uniformity in sickness records may be secured by certain modifications.

It will be observed that these cards conform to actuarial methods, as in general use with life and sickness insurance companies. It is explained that:

From these personnel cards monthly tabular statements can be made showing the number of workers, the number of cases of sickness occurring among them, and the sickness rate per thousand persons, for any group of workers.

By means of certain mechanical aids for identification, the utility of this kind of record can be very materially enlarged. Thus, for illustration, a chosen indication for any illness by means of a red or a blue marker can be attached at the time of entry, to the card, and removed at the end of the month.

The reports required by the Public Health Service, from plant managers or officials of sick-benefit associations, are expected to contain the following information:
There are some additional forms, showing a list of cases of disabling sickness each month, listed separately, but these do not seem to require extended consideration.

The two reports in question provide for the monthly tabulation of the incidence of sickness and its severity, in terms of sick days, of each disease and of all diseases, as may be worked out from the available material. It will be granted that however simple the arrangement, it will meet all ordinary requirements. Special sickness investigations can easily be derived from these fundamental sources, if suggestive of more extended investigation.

Plan B of the United States Public Health Service is a much more simplified method, designed for plants and sickness associations, which find it impossible to keep personnel cards for each employee. It, however, affords a record from which a monthly statement can be made of the number of employees or members of sickness associations, employed in the various operations of the department with which they are connected. This form, however, will often prove insufficient for practical purposes and for special research. Its final analysis general sickness data are of no practical value in connection with investigations that aim at the ascertainment of causes or conditions responsible for the occurrence of particular occupational affections. It is, therefore, to be hoped that the form recommended by the United States Public Health Service will be generally adopted, though subject to modification and improvement in the light of subsequent experience.

Dr. L. F. Hoffmann
(Boston, U.S.A.)

OCCUPATIONAL DISEASE STATISTICS IN EUROPE

The diseases which may result from an occupation may be divided into two principal groups. First, those in which it cannot directly be determined whether they are the result of the occupation, because they are as likely to be due to other causes (e.g. bronchitis, pneumonia), or because the injury caused by the occupation merely creates a tendency to the disease (e.g. phthisis). Second, the diseases which are directly caused by the health risks of the occupation and may therefore be ascribed to it without question, is to say, occupational diseases in the more limited sense — so-called “technopathies” (e.g. pneumoconiosis, anthrax, occupational poisoning). If the term “occupational disease” is taken in the wider sense, including both groups and therefore also tuberculosis, the statistical methods must obviously allow for the differences between the two.
In the first group, it is not possible to distinguish between cases of illness and death connected with the occupation from those not so connected. Consequently, the data in the records of sickness and death must be worked up. Only a higher rate permits of the conclusion that the occupation is a contributory cause, but contemporaneous social, economic, and local influences must also be taken into account. In considering occupational diseases in the more limited sense the object must be to cover all cases of sickness or death in question and relate them to the section of the workers exposed to these dangers. It follows that in the first case use must be made of general morbidity and mortality statistics, while in the second special investigations are necessary, which either may be connected with general statistics, or owing to the rareness of these have to be undertaken separately.

**Dust Hazards.**

Simple dust, not mixed with poisonous materials, such as is inhaled in several occupations, sometimes in large quantities, gives rise to nasal catarrh, inflammation of the throat, bronchitis, pneumonia, or the permanent infiltration of coal, iron, sandstone or silicate dust in the lungs. Frequently, a clinical examination is not sufficient to distinguish between pneumoconiosis and phthisis. The former is not a tubercular disease, but may lead to its development, and is frequently classified under phthisis in mortality statistics. Diseases due to the inhalation of poisonous dust belong to the second group.

Occupational mortality statistics can provide detailed indications only if they cover the causes of death. The only statistics available are the English calculations of mortality made for several decades back, the Dutch statistics for 1908-1911 and the Swiss for 1888 to 1900. The chief difficulty in using these statistics is to make the classifications of occupation in the census and the mortality returns agree. In spite of the various objections which are continually being raised against these statistics, they offer a useful basis for considering the hazards in many occupations. More restricted investigations are often made, but unfortunately the statistical calculations are frequently erroneous.

The most frequent mistake made is that the causes of death due to diseases are calculated as percentages of all deaths. The results of this can be approximately correct only when the general mortality is equally high. Otherwise the results may give quite a false impression. To take an example from the English statistics for 1900 to 1902:

**DEATHS DUE TO PULMONARY TUBERCULOSIS**

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Agricultural labourers</th>
<th>Inn-keepers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per 1,000 living</td>
<td>Per 100 deaths</td>
</tr>
<tr>
<td>25-30</td>
<td>1.13</td>
<td>4.01</td>
</tr>
<tr>
<td>30-35</td>
<td>1.18</td>
<td>4.79</td>
</tr>
<tr>
<td>35-40</td>
<td>1.35</td>
<td>3.25</td>
</tr>
<tr>
<td>40-45</td>
<td>1.50</td>
<td>2.12</td>
</tr>
<tr>
<td>45-50</td>
<td>1.19</td>
<td>2.08</td>
</tr>
<tr>
<td>Over 50</td>
<td>0.77</td>
<td>1.08</td>
</tr>
</tbody>
</table>

The figures show that the mortality from phthisis is very much higher among innkeepers than among agricultural labourers: the percentage figures give quite a wrong impression. A similar remark applies to mortality statistics. It follows that cases of death and disease must always be related to the number of living persons.

In view of the large differences in the age distribution of the persons belonging to the various occupations, this must be taken into account in mortality statistics, as otherwise serious misconceptions would arise. This is less so in the case of the morbidity statistics, as the number of cases of illness does not differ so much with age as that of deaths, but even here the age distribution must be taken into account. The English statistics for 1900 to 1902, for

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1 Since the preparation of this article for publication the methods referred to in connection with mortality statistics for England and Wales have been somewhat modified. The Registrar-General's Decennial Supplement for England and Wales, 1921, describes a change in methods of tabulation followed in the 1921-1923 Report. This change includes a modification in the nature of the population used as standard. Formerly the total male population aged 25-65 was employed, but now there is taken as basis that of occupied and retired civilian males aged 20-65. The reason for extending the age by including the group 20-25 years is stated to be the belief that the average worker has at the age of twenty been long enough subjected to the environmental influences of his occupation to make definite influence upon his mortality possible, and the reason for substituting males engaged in or retired from a civilian occupation for the former total male population is that since the population in each occupation dealt with consists of occupied and retired civilians alone it is therefore more appropriate that the standard of comparison should be similar.

As it has not been possible to reconstruct the present article on the basis of these changes attention is here drawn to the fact that the tables, etc., are in accordance with the former practice.
instance, show the following figures for the age-group 25-65 years:

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Crude death-rate</th>
<th>Standard death-rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal mining</td>
<td>10.75</td>
<td>12.46</td>
</tr>
<tr>
<td>Shipbuilding</td>
<td>12.15</td>
<td>11.51</td>
</tr>
</tbody>
</table>

The differences in the two calculations may be explained by the difference in the age distribution, which was as follows:

**AGE DISTRIBUTION PER 1,000 WORKERS**

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Coal mining</th>
<th>Shipbuilding</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-35</td>
<td>427</td>
<td>351</td>
</tr>
<tr>
<td>35-45</td>
<td>289</td>
<td>272</td>
</tr>
<tr>
<td>45-55</td>
<td>189</td>
<td>219</td>
</tr>
<tr>
<td>55-65</td>
<td>95</td>
<td>158</td>
</tr>
</tbody>
</table>

Since in the age-group 25-65 the frequency of phthisis does not vary so much in the different decades, the crude death-rate gives approximately the right order for the different occupations, as regards mortality but it cannot be an exact measure of mortality. For instance, in England in 1900-1902 the phthisis death-rate figures for the age-group 25-65 years were as follows:

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Crude death-rate</th>
<th>Standard death-rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipbuilding</td>
<td>3.56</td>
<td>3.50</td>
</tr>
<tr>
<td>Coal miners</td>
<td>3.60</td>
<td>3.10</td>
</tr>
<tr>
<td>Coal miners</td>
<td>3.90</td>
<td>3.75</td>
</tr>
<tr>
<td>Textile workers</td>
<td>2.54</td>
<td>2.72</td>
</tr>
<tr>
<td>Shipbuilders</td>
<td>2.41</td>
<td>2.27</td>
</tr>
<tr>
<td>Domestic servants</td>
<td>1.45</td>
<td>1.75</td>
</tr>
<tr>
<td>Fishermen</td>
<td>1.66</td>
<td>1.62</td>
</tr>
<tr>
<td>Farmers and farmers' sons</td>
<td>1.39</td>
<td>1.07</td>
</tr>
</tbody>
</table>

Owing to the comparatively small numbers of persons in the higher age-groups, the crude death-rates are too low for coachmen, coal miners, textile workers, and domestic servants, while for the opposite reason they are too high for shipbuilders and farmers. A similar remark applies to morbidity rates.

The method of calculation is quite simple. The number of males living at the census and aged between twenty-five and sixty-five, yielding a mortality of 1,000 in the census year and the years preceding and succeeding it, was taken as the standard population. For the 1901 census this standard population was for England and Wales 71,005 persons. This figure was then divided in proportion to the figures obtained by the census for each age-group: 25-35 years, 35-45 years, etc. In each occupation covered by the census, the annual mortality rate for the occupied and for each age-group was calculated on the basis of the census returns of the population, and of deaths registered during the three years 1910-1911-1912 in the middle of which the census took place. Then by multiplying the above standard population at each age, and adding for each occupation the figure for each of the four age-groups thus ascertained, a figure is obtained, which represents the comparative mortality, which is accurately comparable with the 1,000 deaths amongst the general population, or with the analogous figures obtained similarly for any of the other occupations.

The following results are obtained for coal-mining and shipbuilding:

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Crude death-rate, 1900-1902</th>
<th>Standard death-rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-35</td>
<td>5.08</td>
<td>0.67</td>
</tr>
<tr>
<td>35-45</td>
<td>7.97</td>
<td>1.33</td>
</tr>
<tr>
<td>45-55</td>
<td>13.19</td>
<td>3.36</td>
</tr>
<tr>
<td>55-65</td>
<td>15.19</td>
<td>5.13</td>
</tr>
<tr>
<td>25-65</td>
<td>14.74</td>
<td>1.67</td>
</tr>
<tr>
<td>35-45</td>
<td>18.74</td>
<td>1.33</td>
</tr>
<tr>
<td>45-55</td>
<td>20.74</td>
<td>3.36</td>
</tr>
<tr>
<td>55-65</td>
<td>22.74</td>
<td>5.13</td>
</tr>
<tr>
<td>25-65</td>
<td>71.005</td>
<td>10.75</td>
</tr>
</tbody>
</table>

Taking the crude rates, the mortality of brewers was higher. Taking the standard rates, it was lower, although the differences were small. They are much larger in the case of respiratory organs, which increases rapidly with advancing age. The figures shown in the table in the next column are taken from the English statistics for 1900-1902.
The English statistics give the standard rates by equating the mortality for all men in 1900-1902 to 1,000 (it was 14.083 per thousand), which gives a death-rate from respiratory diseases of 195 in coal-mining and 161 in shipbuilding. The differences between the crude and standard death-rates would be still larger if persons over sixty-five years of age were included.

The number of expected deaths may also be calculated, but this requires a knowledge of the original data. Assuming that the mortality in the individual occupations is the same as for all men, the death-rate is calculated, the number of expected deaths equated to 1,000, and the proportion of recorded deaths calculated. The English figures for 1900-1902 of deaths due to respiratory diseases in the coal-mining and shipbuilding industries were as follows:

<table>
<thead>
<tr>
<th>Age-group</th>
<th>Death-rate of all men</th>
<th>Shipbuilding</th>
<th>Coal-mining</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number of workers</td>
<td>Number of deaths</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recorded</td>
<td>Expected</td>
</tr>
<tr>
<td>25-35</td>
<td>6.724</td>
<td>61,347</td>
<td>47</td>
</tr>
<tr>
<td>35-45</td>
<td>1.699</td>
<td>47,550</td>
<td>73</td>
</tr>
<tr>
<td>45-55</td>
<td>3.380</td>
<td>38,360</td>
<td>104</td>
</tr>
<tr>
<td>55-65</td>
<td>7.182</td>
<td>27,639</td>
<td>126</td>
</tr>
</tbody>
</table>

In the shipbuilding industry the number of deaths due to respiratory diseases per thousand expected was 922, in the coal-mining industry 1,072. Here, too, it will be seen that the number falls below the expected figure in shipbuilding but exceeds it in coal-mining. If the shipbuilding death-rate is taken as 100, the coal-mining figure will be 116. The calculated standard rates above give the proportion 100 to 122.

In morbidity statistics the cases of phthisis cannot be separated out reliably, as they are recorded under various names (bronchial catarrh, pulmonary inflammation, pulmonary hemorrhage, pulmonary complaints, etc.). It may lead to gross error to try to include cases recorded in sickness fund statistics and classified under different diagnoses. Teleky introduced a very wide classification under phthisis for the sickness statistics of the Rhenish sickness funds: spitting blood, pleurisy, pulmonary disease, pulmonary complaints, bronchitis (prolonged cases of relapse, especially in persons of over fifty years of age). In any case it is advisable to make use of the death-rate statistics as a check. It is therefore better to limit the statistics to those of respiratory diseases. When the number of the acute diseases (angina, bronchitis) is very high it is unimportant whether the cases diagnosed as phthisis are included. It must always be remembered, however, that these diseases are very frequently caused not merely by the inhalation of dust, but also at work in the open air or in overheated rooms.

Sickness funds have no difficulty in establishing the number of cases of illness, but it is not so easy to determine the average membership by age. This requires a census of the members by age and sex, and in seasonal trades an annual census is not enough. One could be taken also at the beginning and one at the middle of the year, so that the three sets of figures would give an average age distribution for the year. The average of the monthly membership figures would give an annual mean. It is more reliable to calculate the number of days of sickness per member; by dividing this total by 365, the number of the average working complement is obtained. This procedure was used for the important statistics of the Leipzig District Sickness Fund. In determining the risk of accidents, or of occupational poisoning and infection, sometimes only the number of days to which such risks apply is used, i.e. about 300 days.

A comparison of the morbidity in different sickness funds is not possible, unless they have the same regulations concerning the payment of sickness benefit, from the first or a later day, on Sundays and holidays, concerning the period of payment and similar matters. A comparison of the morbidity in different trades will mostly have to be confined to one and the same fund. The extent to which the morbidity may differ for different funds in a small district has been shown in Teleky’s statistics for the Rhenish Sickness Funds, and elsewhere.

A third method of determining the frequency of phthisis in an occupation is to examine the whole body of workers employed. Occasionally Lorder-line cases the results of such an examination are very uncertain.
Besides the actual examination of the lung, there should also be a tuberculin test and X-ray photography. The results of different examinations cannot be compared unless they are made by the same person. This method allows only of establishing rough differences.

Although nowadays the dust risks in many occupations have been very much reduced by exhaust appliances, etc., there are still several occupations in which the workers' lives are exposed to serious risks from the formation of dust. Organic dust (flour, wood, wool, or cotton dust) is much less dangerous, as also coal dust, which, strictly speaking, belongs to this group. Tobacco dust is more dangerous, presumably owing to its nicotine contents. Inorganic dust has still the most serious effects in some occupations. The risk run by plasterers and brick and cement workers are not so great, but they are very serious in the case of stone-cutters, china-and pottery workers, basic slag grinders, cutters, file-makers and glass-cutters, and especially in work in which the dust is mixed with poisons such as lead. The first table in the next column shows some of the worst examples from the English statistics for 1910-1912, compared with the favourable figures for miners.

### Ratios in Per cent. of Tuberculosis Deaths to Total Deaths in Occupations Exposed to Mineral and Metallic Dusts

<table>
<thead>
<tr>
<th>Occupation</th>
<th>U.S. Registration Area (Age groups)</th>
<th>Prudential Insurance Company's experience (Age groups)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15-24 25-34 35-44 45-54 55-64 15 and over</td>
<td>15-24 25-34 35-44 45-54 55-64 15 and over</td>
</tr>
<tr>
<td>Coal-mining</td>
<td>38.1 30.9 24.0 14.4 7.6 14.9</td>
<td>33.2 40.9 32.9 19.0 8.8 20.5</td>
</tr>
<tr>
<td>Lead miners</td>
<td>28.1 30.9 24.0 14.4 7.6 14.9</td>
<td>33.2 40.9 32.9 19.0 8.8 20.5</td>
</tr>
<tr>
<td>Tin mines</td>
<td>28.1 30.9 24.0 14.4 7.6 14.9</td>
<td>33.2 40.9 32.9 19.0 8.8 20.5</td>
</tr>
<tr>
<td>Sandstone cutting</td>
<td>28.1 30.9 24.0 14.4 7.6 14.9</td>
<td>33.2 40.9 32.9 19.0 8.8 20.5</td>
</tr>
<tr>
<td>Potteries and china factories</td>
<td>28.1 30.9 24.0 14.4 7.6 14.9</td>
<td>33.2 40.9 32.9 19.0 8.8 20.5</td>
</tr>
<tr>
<td>Cutters</td>
<td>28.1 30.9 24.0 14.4 7.6 14.9</td>
<td>33.2 40.9 32.9 19.0 8.8 20.5</td>
</tr>
<tr>
<td>File makers</td>
<td>28.1 30.9 24.0 14.4 7.6 14.9</td>
<td>33.2 40.9 32.9 19.0 8.8 20.5</td>
</tr>
<tr>
<td>All men</td>
<td>28.1 30.9 24.0 14.4 7.6 14.9</td>
<td>33.2 40.9 32.9 19.0 8.8 20.5</td>
</tr>
</tbody>
</table>

The Dutch statistics for 1908-1911 give the following standard death-rates for the age-group 18-64 years:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Phthisis</th>
<th>Respiratory diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-mining</td>
<td>2.28</td>
<td>0.15</td>
</tr>
<tr>
<td>Glass-cutters</td>
<td>3.30</td>
<td>1.88</td>
</tr>
<tr>
<td>Stone-cutters</td>
<td>3.61</td>
<td>2.08</td>
</tr>
<tr>
<td>Earthenware and china houses</td>
<td>5.16</td>
<td>2.62</td>
</tr>
<tr>
<td>Factories</td>
<td>3.06</td>
<td>0.82</td>
</tr>
<tr>
<td>Compositors</td>
<td>3.31</td>
<td>2.12</td>
</tr>
<tr>
<td>Tobacco workers</td>
<td>3.16</td>
<td>1.00</td>
</tr>
<tr>
<td>All occupations</td>
<td>1.69</td>
<td>0.99</td>
</tr>
</tbody>
</table>

American statistics (Winslow and Greenburg) give the following figures:

The standard death rates for the age-group 25-65 years:

### Standard Death Rate for the Age-Group 25-65 Years

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Phthisis</th>
<th>Respiratory diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-mining</td>
<td>1.90</td>
<td>1.84</td>
</tr>
<tr>
<td>Lead miners</td>
<td>4.72</td>
<td>2.77</td>
</tr>
<tr>
<td>Tin miners</td>
<td>5.55</td>
<td>4.44</td>
</tr>
<tr>
<td>Sandstone cutting</td>
<td>5.85</td>
<td>4.33</td>
</tr>
<tr>
<td>Pottery and china factories</td>
<td>3.95</td>
<td>4.46</td>
</tr>
<tr>
<td>Cutters</td>
<td>6.56</td>
<td>2.97</td>
</tr>
<tr>
<td>File makers</td>
<td>6.11</td>
<td>3.33</td>
</tr>
<tr>
<td>All men</td>
<td>2.00</td>
<td>1.28</td>
</tr>
</tbody>
</table>
The data on which some of the figures are calculated are not very numerous, so that for some occupations the standard deviation is large. Such an incidental cause is probably the reason for the excessively high mortality of glass-cutters from phthisis.

The following figures are taken from the morbidity statistics of the Leipzig Sickness Fund and apply to male employees liable to insurance. The standard rates per 100 members have been calculated for the age-group 15-74 years on the basis of the age distribution of all such members. The morbidity involving incapacity to work was as follows during the year:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Phthisis</th>
<th>Respiratory diseases</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compositors</td>
<td>1.39</td>
<td>6.09</td>
<td>7.48</td>
</tr>
<tr>
<td>Tobacco workers</td>
<td>1.62</td>
<td>6.97</td>
<td>8.59</td>
</tr>
<tr>
<td>Stone-cutters</td>
<td>2.44</td>
<td>10.30</td>
<td>12.74</td>
</tr>
<tr>
<td>Metal polishers and grinders</td>
<td>1.61</td>
<td>7.82</td>
<td>9.43</td>
</tr>
<tr>
<td>All occupations</td>
<td>0.78</td>
<td>5.65</td>
<td>6.43</td>
</tr>
</tbody>
</table>

In occupations with a high death-rate from phthisis all the branches of the trade are not equally exposed to the risk of this disease. Among cutters, for instance, the grinders run greater risks, in china factories the actual china workers, etc. An effort should therefore be made to establish separate statistics for the more affected branches in such dangerous undertakings. This has been done for instance by Kölsch and Thiele for china factories. Thiele publishes the following figures for four German china factories for 1914-1919:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Number of workers in full working complement</th>
<th>Number of workers in full working complement</th>
<th>Number of workers in full working complement</th>
<th>Number of workers in full working complement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tobacco workers</td>
<td>637</td>
<td>8.60</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Stone-cutters</td>
<td>348</td>
<td>5.91</td>
<td>0.35</td>
<td></td>
</tr>
</tbody>
</table>

Both came to the conclusion that pneumoconiosis was to be found after five years' work, after which it increased rapidly in frequency. Thiele found that out of 63 workers who had been employed for over thirty years, 45, or 71 per cent., suffered from this disease.

### Occupational Poisoning

The ideal to be aimed at is to cover all cases of occupational poisoning. Unfortunately, it is far from realised anywhere. As a rule, the only cases of acute poisoning which become known are those involving an interference, perhaps small, with working capacity. It is generally impossible to establish the existence of occupational poisoning without a medical examination, but frequently doctors are not sufficiently trained in industrial hygiene to recognise all cases of such poisoning, especially the rarer kinds. It has therefore been justly urged in many quarters that doctors should be better trained in industrial hygiene, an observation which applies equally to all civilised States.

There are various methods of arriving at the number of cases of occupational poisoning.

### Compulsory Notification

Hitherto this has been introduced in only a few States, amongst others in Switzerland, the Netherlands, England and certain of the United States, France and the U.S.S.R. It is a well-known fact that even where notification is compulsory, all cases are far from being notified. It would be wrong for
this reason to give up such notification or to reject its introduction, but it should be made to cover only poisonings which can be definitely and easily diagnosed. The statistical material thus obtained will not be large but it will give an approximate idea of the frequency of poisoning in individual undertakings and an indication of increase or decrease. In England, the notified cases are classified by occupational groups. Thus, in 1920 the number of notices of lead poisoning per thousand workers was 26 in white lead factories, 27 in accumulator factories, 20 in tinning factories, 16 among painters, 2 among filemakers, and 0.4 among printers. From 1900 to 1929 the undertakings liable to notify in Great Britain gave notice of 13,774 cases of lead poisoning, involving, 1,815 deaths (see article "Occupational Diseases: Definition and Compensation"). The relatively high figure of deaths suggests that mainly serious cases were notified.

**Sickness Fund Statistics**

These can only be considered in countries in which insurance is compulsory. If sickness funds are to be in a position to supply at all reliable statistics, the sickness certificates must contain under a separate head particular information about occupational diseases, and a medical diagnosis must be made at the end of the illness, since at the beginning the doctor is often unable to give a definite judgment. As already explained, membership figures are necessary, based on a proper calculation of averages. A separation into age-groups is desirable, but is not so important as for diseases due to dust. It is very important that at least in large undertakings there should be a classification by the branch of occupation, as not all workers in the undertaking are equally exposed to the risk of poisoning. Sickness fund statistics give always the number of cases of illness, not of sick people. Thus a relapse is counted as a second case. Often the chronic sequelae of lead poisoning such as nephritis, diseases of the vascular system, nervous complaints, are classified under the head of diseases of the organs affected. Among others, Teleky has drawn particular attention to this point in his work on industrial lead poisoning in Austria.

A few examples may be given from the German and Austrian sickness fund statistics. In the important Leipzig statistics, which cover the period 1887 to 1905, the figures for the printing trades, tinsmiths and painters are higher and lend themselves to more detailed statistical treatment. The total number of cases of poisoning in the individual trades are given, but in this particular connection it may certainly be taken for granted that they are all cases of industrial lead poisoning.

For a thousand members subject to compulsory notification there occurred during the year the following cases of lead poisoning:

<table>
<thead>
<tr>
<th>Age-group</th>
<th>All occupations</th>
<th>Compositors</th>
<th>Printers</th>
<th>Lithographers, engravers and other engravers</th>
<th>Typefounders</th>
<th>Tinsmiths</th>
<th>Painters and varnishers</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-24</td>
<td>2.38</td>
<td>39.0</td>
<td>10.8</td>
<td>7.9</td>
<td>43.7</td>
<td>2.9</td>
<td>40.4</td>
</tr>
<tr>
<td>25-34</td>
<td>4.45</td>
<td>50.8</td>
<td>11.4</td>
<td>9.2</td>
<td>60.6</td>
<td>5.2</td>
<td>75.7</td>
</tr>
<tr>
<td>35-44</td>
<td>4.32</td>
<td>54.7</td>
<td>5.9</td>
<td>16.9</td>
<td>56.7</td>
<td>11.9</td>
<td>72.5</td>
</tr>
<tr>
<td>45-54</td>
<td>3.84</td>
<td>50.2</td>
<td>26.8</td>
<td>24.1</td>
<td>75.2</td>
<td>5.3</td>
<td>79.2</td>
</tr>
<tr>
<td>55-64</td>
<td>3.91</td>
<td>58.1</td>
<td>3.7</td>
<td>36.1</td>
<td>78.5</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>65-74</td>
<td>2.20</td>
<td>17.0</td>
<td>—</td>
<td>18.4</td>
<td>—</td>
<td>—</td>
<td>137.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age-group</th>
<th>All occupations</th>
<th>Compositors</th>
<th>Printers</th>
<th>Lithographers, engravers and other engravers</th>
<th>Typefounders</th>
<th>Tinsmiths</th>
<th>Painters and varnishers</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-74</td>
<td>3.54</td>
<td>43.8</td>
<td>11.0</td>
<td>10.2</td>
<td>55.2</td>
<td>5.8</td>
<td>61.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard morbidity</th>
<th>All occupations</th>
<th>Compositors</th>
<th>Printers</th>
<th>Lithographers, engravers and other engravers</th>
<th>Typefounders</th>
<th>Tinsmiths</th>
<th>Painters and varnishers</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.54</td>
<td>43.0</td>
<td>11.0</td>
<td>12.3</td>
<td>55.1</td>
<td>5.5</td>
<td>61.7</td>
<td></td>
</tr>
</tbody>
</table>

The figures speak for themselves. The differences in the age-groups are small, so that the standard rates differ only slightly from the crude rates. There are wide differences for the separate occupations in the printing industry. The actual printers are least exposed to risk. Assistants are not included in the table; the figures for them are even lower. It may be added that out of 3,332 cases of chronic lead poisoning there were only 29 deaths during the whole period under consideration. The average period of incapacity for work due to lead poisoning was 34.8 days.

1 It should be stated that compulsory notification of lead poisoning among painters (since 1904) as well as the occurrence of numerous cases during the operation of dismantling old ships has affected the totals for the subsequent years.
According to Hahn, the number of cases of sickness from lead poisoning in the Berlin District Sickness Fund from 1901 to 1909 per thousand men members was as follows for the printing trades:

- General
- Journeymen and apprentices
- Assistants
- Typefounders

Teleky supplies the following figures for the Vienna Trade Associations’ Industrial Sickness Fund:

<table>
<thead>
<tr>
<th>Cases of Sickness from Lead Poisoning per Thousand Members, 1902-1906</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painters and varnishers</td>
</tr>
<tr>
<td>Printers</td>
</tr>
<tr>
<td>Potters</td>
</tr>
<tr>
<td>Small tool makers</td>
</tr>
</tbody>
</table>

In Germany, a classification by undertaking was made in the chemical industry, first by Grandhomme and Leymann. Subsequently, Curschmann compiled statistics for 1909-1910, at the request of the Trade Insurance Association for the Chemical Industry. The number of workers averaged 52,000, and the number of cases of occupational illness in the year was 181.5 or 3.4 per thousand. The workers were classified into various groups; no cases of occupational diseases were found among office or women workers. The following figures were calculated for the remaining groups:

<table>
<thead>
<tr>
<th>Number of times ill</th>
<th>Number of persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>458</td>
</tr>
<tr>
<td>2</td>
<td>116</td>
</tr>
<tr>
<td>3</td>
<td>48</td>
</tr>
<tr>
<td>4 or more</td>
<td>74</td>
</tr>
</tbody>
</table>

Total 691

<table>
<thead>
<tr>
<th>Period of illness (Weeks)</th>
<th>Per cent. of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or less</td>
<td>19.2</td>
</tr>
<tr>
<td>2</td>
<td>18.7</td>
</tr>
<tr>
<td>3</td>
<td>16.7</td>
</tr>
<tr>
<td>4</td>
<td>13.2</td>
</tr>
<tr>
<td>5 or more</td>
<td>30.2</td>
</tr>
</tbody>
</table>

General Statistics of Causes of Death

Where the causes of death are notified by doctors, these statistics may give information as to the cases of poisoning which are more likely to be fatal. Detailed figures are available only in the case of the English occupational mortality statistics. In England, from 1910 to 1912, 292 deaths among men were ascribed to lead poisoning, or 0.8 per 100,000 persons living of over fifteen years. The absolute figure was highest for painters, with 140 deaths. The proportion per 100,000 living was highest in lead ware factories where it was 106.2, in the zinc industry with 77.9, among painters with 24.6, potters with 21.3, file makers with 18.3, and glass workers with 12.3. In the Dutch occupational mortality statistics, all cases of poisoning are taken together, but the statistics give the impression that in cases of chronic lead poisoning the complicating diseases are recorded as the causes of death, for the figures apply to a hospital. They give, however, a general idea of the occupations which are liable to serious poisoning. An investigation of this kind was made by Kaup for the cases of lead poisoning in Prussian hospitals from 1904-1908.

Medical Examination of Groups of Workers

This provides no information on acute poisoning, but brings to light cases of chronic disease. It was the only way by which Teleky could establish reliable statistics of the frequency of phosphorus necrosis, which has now almost disappeared. An examination of this kind was made in Bavaria. According to Abelsdorff, over 5,000 painters (masters and journeymen) were interrogated as to their illnesses involving incapacity for work during the period 1907-1910; 691 or 13.8 per cent. had suffered from some disease due to lead poisoning. The following particulars may be given:

General Statistics of Causes of Death

Hospital Statistics

Although these have the advantage of certain diagnosis, they are not very suited to statistical treatment as it is unknown what proportion of the sick workers or women workers. The following figures were calculated for the remaining groups:

<table>
<thead>
<tr>
<th>Average cases of occupational poisoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full working cases</td>
</tr>
<tr>
<td>Artisans</td>
</tr>
<tr>
<td>Day workers on machines</td>
</tr>
<tr>
<td>Workers in factories for inorganic products</td>
</tr>
<tr>
<td>Workers in factories for organic products</td>
</tr>
<tr>
<td>Dyeworks, laboratories</td>
</tr>
</tbody>
</table>

Only a few lead-colour factories were covered by these statistics. In these there were more cases of poisoning.
of death from poisoning in lead occupations are very low.

Other Occupational Diseases

There are several other occupational diseases which cannot be discussed in detail here, such as occupational eczema, caisson disease, glass makers’ cataract, occupational myopia, tumour of the gall-bladder in tanneries, chimney sweeps’ cancer and other tumours due to permanent irritation, X-ray disease, etc. A brief note may be given of some of the more important.

Ankylostomiasis

The cases of this disease in tanneries, brush factories, etc., are so isolated that figures of its frequency cannot be established unless its notification is made compulsory. If individual undertakings are examined, those occupations which are alone exposed to infection must be separated out. For instance, according to Smyth, in the 57 cow-hide tanneries in Pennsylvania, only 614 of the 7,458 workers were exposed to infection, of whom 59 suffered from anthrax in the period 1916-1920, or 1.9 per cent. per annum. In the 19 goat-hide tanneries, 426 of the 5,881 workers were exposed, and 32, or 1.5 per cent., fell ill.

Miners' Nystagmus

The data on the frequency of this disease vary considerably according to whether slight cases are included or not. If they are, Ohm estimates that 10 per cent. of all miners suffer from nystagmus; and that the serious cases are rare. According to Llewellyn, the figures for England rose when compensation was enforced. The only method of obtaining information on the frequency of nystagmus is to examine all the hewers.

Ankylostomiasis

This disease is widespread in warm countries. In the temperate zone it is an occupational disease of miners and brickworkers. It is easy to establish its frequency by an examination of all the workers for eggs in the stools; the campaign against the disease is on this account easily waged.

Conclusion

The statistics of occupational diseases like medical statistics in general, are still very open to improvement. The results of valuable investigations in individual countries have been published, giving an approximate view, but it is still far from possible to compare the figures for the different countries, whether they relate to morbidity or mortality. Nor is it at all probable that a change may be expected soon, for even if the principles of international statistics were agreed, their proper compilation would depend on several conditions. The first thing that can be achieved is at least to make the investigations in the different countries on uniform lines. This involves the compulsory notification of those occupational diseases, in the more limited sense of the term, where the cause of illness may be clearly defined; and in countries where workers’ insurance is compulsory, or there are important factory sickness funds, the obligation of the fund to notify a specified authority of all cases of occupational disease, and in the death statistics to indicate specially any causes of death which may be connected with an occupational disease in the more limited sense (e.g. poisoning, anthrax).

The compilation of occupational mortality statistics, such as that customary in England for the last seventy years, should be general where possible, for this procedure alone allows of a proper establishment of the mortality from phthisis for different occupations. It is essential that the generation of doctors now growing up should be given training in regard to occupational diseases which might be included in their ordinary curriculum. It is however still more important that these doctors who already have a practice, and are more likely to have to deal with cases of occupational disease, should attend continuation courses in industrial hygiene. Any man who wishes to become an industrial doctor must obviously receive a thorough training in this respect. The medical faculty in general will keep in touch with the latest developments in regard to this question, by maintaining up-to-date knowledge of conditions through publications and lectures relative to the problem of occupational diseases and their probable development.

A consciousness of the defective knowledge of occupational diseases does not constitute a reason for relaxing the efforts to improve the statistics on the grounds that they can never be made perfect; on the contrary, this should act as a spur to extend such knowledge and make it as complete as possible.
### AMERICAN MORTALITY STATISTICS

#### Deaths of persons engaged in certain specified occupations

<table>
<thead>
<tr>
<th>Occupations and age-groups</th>
<th>All causes</th>
<th>Typhoid fever</th>
<th>Tuber-</th>
<th>Cancer</th>
<th>Apoplexy and paralysis</th>
<th>Heart disease</th>
<th>Pneumonia</th>
<th>Bright's disease</th>
<th>Suicide</th>
<th>Accidents</th>
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<td>9.1</td>
<td>2.5</td>
<td>9.3</td>
<td>13.7</td>
</tr>
</tbody>
</table>

1 The mortality figures by age-groups are taken from the statistics on occupational mortality for workers with at least ten years' experience, published in 1909 by the Census Office in the United States.

2 The mortality figures quoted in the first line of each group, and referring to workers with upwards of fifteen years' experience, are taken from a publication by L. G. Dublin and represent data furnished by the Metropolitan Life Insurance Company, Industrial Department, for the period 1911-1913 (U.S. Department of Labour. Bureau of Labour Statistics, Bulletin No. 207, 1917).
### OCCUPATIONAL DISEASES

#### AMERICAN MORTALITY STATISTICS (continued)

<table>
<thead>
<tr>
<th>Occupations and age-groups</th>
<th>Deaths of persons engaged in certain specified occupations</th>
<th>Per cent. of all causes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All causes</td>
<td>Typhoid fever</td>
</tr>
<tr>
<td>Painters and varnishers</td>
<td></td>
<td></td>
</tr>
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<td>25-34</td>
<td>2,722</td>
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<td>35-44</td>
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<td>45-54</td>
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<td>Plumbers</td>
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<tr>
<td>Textile mill workers</td>
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<td>45-54</td>
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<td>1.5</td>
</tr>
</tbody>
</table>

According to the returns of the Metropolitan Life Insurance Company (Industrial Department) for the period 1911-1913 the average age at death by occupation was as follows:

### Men

- Bookkeepers and office assistants: 36.5
- Engine men and trainmen (railway): 37.4
- Plumbers, gasfitters and steam fitters: 39.8
- Compositors and printers: 40.2
- Teamsters, drivers and chauffeurs: 42.3
- Machinists: 43.9
- Textile mill workers: 47.6
- Iron moulders: 48.0
- Painters, paper hangers and varnishers: 48.6
- Cigar makers and tobacco workers: 49.5
- Bakers: 50.6
- Coal miners: 51.3
- Labourers: 52.8
- Masons and bricklayers: 55.0
- Blacksmiths: 55.4
- Farmers and farm labourers: 56.5

**Average for all occupations specified:** 47.9

### Women

- Clerks, bookkeepers and office assistants: 36.1
- Store clerks and saleswomen: 28.0
- Textile mill workers: 33.9
- Dressmakers and garment workers: 42.0
- Domestic servants: 49.1
- Housewives and housekeepers: 53.3

**Average for all occupations specified:** 54.1

Lee K. Frankel, of the Metropolitan Life Insurance Company, has studied the mortality and morbidity statistics of the Local Sickness Fund of Leipzig (1887-1904), from which he extracted the following figures, presented at the Detroit Conference in 1913. There are given hereunder the figures relative to the occupational groups cited above:

### Italian Statistics

The National Fund for Social Insurance has studied the causes of illness amongst its members during a period of four years. The records comprise 21,000 sick or retired members. 20,515 of the cases having been followed closely and made the subject of detailed study, 16,606 of the latter were men.

The following diseases affecting men and women, and expressed as percentages of 100 causes of sickness, show values as hereunder:
Infections and poisoning 1.48  
Diseases:  
Blood and nutrition 3.25  
Nervous system 13.25  
Respiratory passages 9.00  
Circulatory system 34.19  
Digestive system 3.37  
Urinary-genital system 2.00  
Locomotory apparatus 4.94  
Skin and tissues 0.63  
Violent accidents 3.88  
Pulmonary tuberculosis 9.61  
Other forms of tuberculosis 1.47  
Tumours 2.22  
Hernia 3.78  

Total 100.00

For 100 sick members of all ages, sickness showed the following percentages per age-group:  
- 20 years of age and under: 0.34  
- 21-30: 4.40  
- 31-40: 6.12  
- 41-50: 8.40  
- 51-60: 22.45  
- 61-70: 58.39  

An analysis of the different causes of sickness gives the following figures for men, for diseases of the circulatory apparatus: 7,014 cases (3.96 per cent. for those under fifty years of age; 17.63 under sixty years of age, and 77.45 between sixty-one and seventy). Separating occupational groups these diseases were found to occur in the ratio of 50.69 per cent. amongst industrial workers; 16.62 per cent. amongst labourers and others; 12.78 per cent. amongst domestic servants, and 10.20 amongst workers engaged in agriculture hunting and fishing.

As regards nervous diseases there occurred amongst the men 2,283 cases: 8.72 under the age of forty years, 11.52 under fifty, 31.32 under sixty, and 48.44 under seventy. Cases were more numerous amongst the "industrial workers", followed in order by "agricultural workers", "labourers", "domestic servants".

Tuberculosis and other tuberculous diseases totalled 1,381 for the men and 590 amongst the women. The proportion of men suffering from incapacity for work was as follows: under the age of twenty, 1.73; under thirty, 22.15; under forty, 25.80; under fifty, 20.27; under sixty, 18.32; and under seventy, 11.73.

For women the proportions were respectively 3.40, 37.45, 21.70, 18.98, 13.05, and 5.42.

For both sexes these diseases affected the group of "industrial worker" in the proportion of 60.02 per cent., "labourers" in that of 11.16, "agricultural workers" 9.53, and "domestic servants" 8.93.

**Respiratory diseases** attacked 1,858 persons of both sexes and, whilst they affected only 3.97 per cent. of the members under forty, 5.17 in the age-group 41-50 were affected, 17.0 in the age-group 51-60, and 66.74 in the age-group 61-70.

The order of frequency as regards occupational category was as follows: "industrial workers", "labourers", "agricultural workers", "domestic servants".

For further details see the study made by Emilia Sorrentini appendix No. 4, 1926, of the periodical *Le assicurazioni sociali*, Rome.

**Swedish Statistics**

Occupational morbidity for the period 1913-1916 (figures relative to 100 of the standard population) are given in the following table:

<table>
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<tr>
<th>Incidence of</th>
<th>Accidents</th>
<th>Diseases</th>
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<tbody>
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<td>1.61</td>
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</tr>
<tr>
<td>Foresters and lumbermen</td>
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<td>7.18</td>
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<tr>
<td>Fishermen</td>
<td>0.60</td>
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<tr>
<td>Stoneworkers</td>
<td>3.33</td>
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</tr>
<tr>
<td>Miners (iron and other metals)</td>
<td>5.18</td>
<td>9.29</td>
</tr>
<tr>
<td>Coal miners</td>
<td>4.21</td>
<td>9.79</td>
</tr>
<tr>
<td>Iron and steel foundry workers</td>
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<tr>
<td>Metal foundry workers</td>
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<td>Tinsmiths</td>
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<td>Wood sawyers</td>
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</tr>
<tr>
<td>Masons and plasterers</td>
<td>1.74</td>
<td>4.85</td>
</tr>
<tr>
<td>Painters and varnishers</td>
<td>0.90</td>
<td>5.61</td>
</tr>
<tr>
<td>Mechanics (railway)</td>
<td>1.09</td>
<td>7.36</td>
</tr>
<tr>
<td>Railway workers</td>
<td>2.22</td>
<td>6.15</td>
</tr>
<tr>
<td>Tramway workers</td>
<td>1.38</td>
<td>10.61</td>
</tr>
<tr>
<td>Dockers</td>
<td>5.00</td>
<td>5.86</td>
</tr>
<tr>
<td>Workers (not specified)</td>
<td>2.57</td>
<td>5.87</td>
</tr>
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don, 1908, and Supplement to the 75th

Prof. Prinzing (Ulm).

Clinical Examination

French: Interrogatoire de l'ouvrier. —
German: Befragung des Arbeiters: —
Italian: Interrogatorio dell' operato.
—Spanish: Interrogatorio del obrero.

When a medical man undertakes the
examination of a worker (child, young
person or adult), he ought to follow the
dictates of modern medicine and hy-
giene and consider the possibility of
risk, even where no disease is rec-
ognised as occurring in connection
with the occupation.

Before commencing, the medical man
put a series of questions sug-
gested by the trade or special occupa-
tion of the worker. He should ask
his patient questions, remembering the
action that different substances he may
be called upon to handle, as well as
the special processes used in the fac-
tory, can exercise on the system. He
should never lose sight of the risks
which may be suspected of affecting
the health of the worker. He should
be able to envisage rapidly the pro-
blems which the technical processes
involve, in order to arrive at an
etiological diagnosis by the same me-

 Method of deductive reasoning, almost
unconscious and automatic, which will
lead him to form his ordinary diag-
nosis. It should be remembered that
Hippocrates, in the earliest dawn of
medicine, realised the importance at
the start of asking the patient about
his family history. After many cen-
turies a notable advance was made by
Ramazzini, for whom a knowledge of
the occupation of the worker was
not a matter simply of curiosity or a
dry addition to the clinical history of
the patient. He started with an exact
knowledge of industrial maladies and
sought out in the various occupations
the elements which might explain the
subjective and objective symptoms in
the individual and the extent to which
these symptoms could be attributed to
the occupation.

To-day these data relating to the past
history of the worker are a little too
simple to suffice. A medical examina-
tion is even desirable for persons
apparently healthy before commencing
employment as well as periodically
during its course, and especially when
a transfer to other work occurs.

A thorough knowledge of the family
and personal history will give the
medical man the necessary data for
determining the adaptability of the
subject's resistance to the occupation
in question. A knowledge of the
habits and customs of the subject
which may vary considerably from the
usual will enable the physician to make
suggestions and give advice which
'gether may help to start the patient
on sound lines.

It is unnecessary to insist on the
value of information as to the health
of the parents and members of the
family, and of illnesses contracted
during childhood. Nowadays it is in-
dispensable on the other hand to
request information as to excessive zeal
in sport and to put questions on the
subject of important diseases which
the patient has survived: how they
variably, the period of convalescence,
medical supervision throughout their
duration, etc.
Among the maladies and anterior troubles to which special attention should be given are the following:

(a) **Acute articular rheumatism:** possibility of recurrence, endocarditis, and especially myocarditis more or less circumscribed and capable of manifesting itself much later in life (granulomas of Aschoff-Tawara). The precursory and occasional phases of chronic arthritis should not be lost sight of.

(b) **Pharyng-o-tonsilitis:** possibility of albuminuria, and relapses with nephritis and rheumatism.

(c) **Typhoid fever:** possibility of the patients being carriers and dangerous disseminators of germs; exposure to affections of the abdominal organs, especially when the person in question indulges to excess, and does not follow the prescribed diet during the period following convalescence.

(d) **Scarlet fever:** possibility of the kidneys being affected and predisposition to kidney disease.

(e) **Dermatitis:** erythema, eczemas, possibility of allergic states.

(f) **Venereal and syphilitic diseases:** a negative reply to the question has no value even when made in good faith. Among workers in large industrial towns, for example, it was found that of 100 positive Wassermann reactions 66 occurred amongst persons who were ignorant that they had contracted the disease (Devoto, Milan).

(g) **Diseases and affections which might be considered as precursory to a disease of a tubercular character** (pleurisy, adenitis, periostitis).

(h) **Tremor:** possibility of hereditary syphilis, endocarditis, neuropathy.

It is wise to enquire if the individual has suffered from accidents, their frequency, importance and consequences; whether his brothers and sisters have also been subject to accidents. In the case of workers in the transport industry, enquiry should be made if they have suffered from repeated accidents. The medical man should verify whether the subject has lost weight and in some cases (e.g. poisoning by carbon bisulphide) he should look at photographs taken at a year’s interval, to see if there is any evidence of wasting.

When it is a question of work at high temperature or in a very humid atmosphere, the doctor should make enquiries as to the function of perspiration from the skin (whether it is abundant) and as to the sensation of thirst, nature of the liquids drunk (water or other drinks).

In the same general way questions should be addressed as to whether work has been done in foreign countries or in mines, or whether the father of the subject has practised one of these trades and whether when young the subject in question went with his father to work. The doctor should satisfy himself as to whether the workman was fit for military service and, if he was not, what was the reason for his discharge; if, during military service, he has kept in "good health", "better health" or "poor health" as compared with his civilian life; as to whether he has been rejected by an insurance company.

When it is a question of a married workman, it is desirable to know the date at which marriage was contracted, the wife’s profession, whether there are children or not, their state of health and occupation, whether it is or is not the same as their father’s. If some of the children have died enquiry should be made as to the age at which death occurred and its cause; enquiry should also be made as to any miscarriages or premature births.

When the patient is a woman the doctor should enquire of her as to the date of commencement of menstruation, regularity or irregularity, if any, in regard thereto (pain, haemorrhages), date of marriage and pregnancies, number and state of health of children, and miscarriages, if any. He should enquire further as to the deliveries were normal, and if the menstrual functions have been disturbed since pregnancy and whether industrial work has been excessively trying during the periods of menstruation, pregnancy and nursing. In the case of a patient who has had miscarriages it is necessary to ascertain very tactfully, without of course noting down whatever replies may be elicited, whether all miscarriages were involuntary. Finally, it is necessary to ascertain also the husband’s occupation and to determine the absence or presence in the past of venereal diseases (Wassermann). In many cases it is advisable to have the advice of a gynaecologist.

A doctor who, in examining a young girl, is led to suspect the existence of a former or actual pregnancy should not pursue his enquiry further unless a very urgent reason exists for going more deeply into the question.

Subsequent to these questions of a rather general order the doctor should pass on to questions of an occupa-
When he is aware of the industry or occupation of the patient under examination, he will be able, except under special circumstances, to form an idea of the diseases which such work may cause or has already caused in the case of his patient. This pathology may be classified as follows:

(a) Poisonings. — The precise questions the doctor should put to sick persons exposed to the risk of industrial poisoning must be obvious. He ought to take into account the special occupation, nature of the environment, as well as all that relates to the workman: his personal cleanliness, his observation of prophylactic measures at work, etc. It must be confessed that in some cases the concomitant action of several noxious causes may make the diagnosis very difficult and that, in others, the use of new products or of those the toxic action of which is not known may create difficulty in finding out what the cause of the damage has been.

(b) Infections. — This group is dominated by ankylostomiasis, anthrax, glanders, tuberculosis (cutaneous) (see these articles and the article “Infections”).

(c) Pulmonary pathology due to dusts. — The questions should be directed towards the special work of the workman (in mines, quarries, etc.), the environment of the work, organisation of preventive measures (ventilation, breathing apparatus, humidification, periodic medical inspection, etc.), and the nature and quantity of the dust.

(d) Pathology due to physical and meteorological causes, etc. — This section comprises very varied industrial conditions: very hot atmospheres, hot and humid atmospheres, cold temperatures — when the heat-regulating centres of the individual are strained to the utmost in order to maintain the physiological temperature of the body (Hill, Dorno); occupations where disagreeable smells are produced which may end by setting up general gastric pathological symptoms; work setting up increase or diminution in arterial pressure in consequence of the accomplishment of more or less arduous efforts; operations that are always the same and therefore monotonous; those demanding constant attention; those bringing into play special irritative stimulation of the skin, etc.

Finally it is desirable to ask the patient if he has knowledge of any malady or symptoms analogous to those from which he is suffering amongst the members of his family or amongst his companions at work.

With the object of facilitating the work of the industrial physician, lists or tables have been prepared where the industrial diseases are enumerated together with their most important symptoms.

Some of these publications occasionally give an alphabetical list and beside each symptom are enumerated those industrial diseases in which it is possible for them to occur.

Prof. L. Devoto
(Milan).

EXTRACT FROM THE CASE SHEET USED AT THE LABOUR CLINIC IN MILAN.

(Pages 2 and 3)

Information relative to Food and Habitation

FOOD:

Number and hours of meals ............................................................
Usage of cold food ..................................... liquids .................................. carbohydrates ..................................
Abuse of wine .................................. liqueurs .................................. drinks in general ..................................
Approximate daily expenditure ..........................................................
Does the workman smoke .................................. chew tobacco .................................. Other abuses ..................................

HABITATION:

Is it healthy? ................................................................
Number of rooms for persons. How many beds per room? ..................................
Which room is used for working in? ..................................
Lighting .................................. Heating ..................................

INFORMATION AS TO OCCUPATION:

Exact description of occupation ..........................................................
Raw materials, accessories, machinery, tools ..................................
Is dust given off? (which?)
Are vapours given off? gas?
Must the workman adopt special attitudes for working?
Must he make great efforts?
Is the work in a factory or at home?
Hours of work in factory or home .. and at home.
Rest periods.
Supplementary work.

PLACE OF WORK:
How many persons are employed?
Number of windows.
Lighting Heating. Ventilation.
Fans. Where applied.
Are wages paid by the piece or by the day?
Annual total compulsory unemployment.
What does the workmen do during periods of unemployment?

CHART FOR PERSONAL HEALTH DATA
(From the Division of Industrial Hygiene, Ohio State Department of Health 1)
Prepared by Emery R. HATHURST, M.D.

Note: Use X for slight defect; XX more marked; very marked XXX. R, right, L, left, as required.

DATE

IDENTIFICATION:
Date of immigration. Time in this vicinity. Apparent age.
Degree of intelligence. Ability to understand English.
Miscellaneous.

PREVIOUS HEALTH:
Medical or surgical attention, especially since 12 yrs. of age such as: Diseases.
Venereal disease.

PRESENT HEALTH (Complaints):

HABITS:
Present.
Past.

FAMILY:

INTEREST:
In own health. Miscellaneous.

PHYSICAL EXAM. — HEAD:

FACE:

EYES (Snellen Chart):
Without glasses. With glasses. Colour blindness.

EARS:

Tender mastoids. Scars.

1 Kober and Hathurst: Industrial Health, pp. 1070-1071. Printed on stiff yellow card, 5 x 8 inches.
OECCUPATIONAL DISEASES

CLINICAL EXAMINATION

NOSE:
Obstructed breathing.......... Nasal voice.......... Ozena.......... Deformity.......... 

LIPS:
Colour.................................. Movements.................................. Defects..................................

TEETH:
Tartar.................................. Caries.................................. Irregularity.......... Malocclusion.......... Absence..........
Odour.................................. Dental work.................................. Use of brush..................................

GUMS:
Rrtraction................ Redness................ Pyorrhoea............ Discoulour......... Atrophy.......... 

TONGUE:
Coated........................ Defects........................ Movements........................ 

PALATE:

UVULA:

TONSILS:

PHARYNX:

VOICE:

TEMPERATURE:

PERSONAL HEALTH DATA (continued)

NECK:
Goiter.............. Glands.............. Pullsations.............. Scars.............. Movements..............

CHEST:
Skin affections........ Flatness............. Sunken apices........ Emaciation........ Limited expansion........ Suspicious breathing.......... Bronchitis........ Pleurisy........ Tuberculosis........
Pneumonia.......... Emphysema........ Stoop........ Spinal disease.......... Breasts.......... Deformity........
Valvular disease.......... Myocarditis........ Pericarditis........ Misc........

ABDOMEN:
Skin affections........ Adiposity........... Distension.............. Dullness (flanks)........
Ventral hernia......... Liver?.............. Gall bladder?........... Spleen?........
Kidneys?.............. Visceroptosis...... Tender points........... Abnormal swellings........
Scar........................ Lumbar or sacroilitic affections........

PELVIS, GENITALS AND RECTUM:
Hernia?.............. Patency of ring?......... Adenitis........
Varicoocele........... Hydrocele............ Deformities............. Venereal diseases........ Haemorrhoids........ Fistula........ Misc........ Defects or disease of female organs........

EXTREMITIES:
Deformities............ Scars................ Ucers................ Varicose veins........
Skin affections........ Oedema............. Arches.............. Toes.............. Toe nails........
Soles?................. Pulse at ankles........ Patellar reflexes........ Ataxia........
Fingers?.............. Hands?.............. Wrists?.............. Arms?.............. Pulse (both wrists)........
Arteriosclerosis (radial, brachial)?........ Glands........ Misc........

BLOOD PRESSURE:
Before exercise............... After exercise............... 

SYSTOLIC.............. DIASTOLIC.............. Pulse pressure...........

URINE:
Appearance............... Sp. gr............... Reaction.............. Sediment........ Albumin........
Reducing substance........ Indican.............. Microscope............... 

MENTALITY TESTS:
Day................ Month.............. Date.............. Year................ Place............. Ship........

Months in year........ Names.............. Days in week........ Names........ Backward........

Counts 1-20?........ Counts 20-1?........ Mistakes.............. Répeats figures........

Grasps funny story........ Construction blocks........ Cube test: Line........ Trials........

Reverse.............. Alternates........ Mathematics............ Binet age........

MISC.
SUMMARY:
DISPOSITION:

Signed:.................................

Circulatory System


Occupational pathology of the cardiovascular system is very important from the point of view of industrial medicine. Nevertheless it has not, and cannot, possess clear and precise outlines and does not exhibit premonitory signs to the medical man, since neither pathological anatomy nor clinical experience have furnished, up to the present time, as does electro-cardiography, positive data relative to the earliest changes in the myocardium. Clinical experience has for long led to suspicion and even recognition that, however far from constituting acute myocarditis and interstitial myocarditis; experimentally they have been shown to occur in the cardiac muscle of tired rats, proving that such alterations are capable of being repaired and eliminated (Cesa-Bianchi).

At the present time it is possible to determine, by means of electro-cardiography, the functional capacity of the heart of an athlete, for example, and to forecast his chances of success in a race; but it is not yet possible to construct a picture of the initial alterations in the myocardium which is at a result of work, circumscribed modifications are produced in the myocardium (similar to those which Aschoff has discovered in acute articular rheumatism, etc.). Observations, made during the war, point to the probability of such slight and sparse alterations, which however are far from constituting acute myocarditis and interstitial myocarditis; experimentally they have been shown to occur in the cardiac muscle of tired rats, proving that such alterations are capable of being repaired and eliminated (Cesa-Bianchi).

The above preamble is of import since occupational pathology of the heart relates mainly, if not even exclusively, to the heart muscle, its vessels and nerves, and since there is reason to believe that this pathology, which is in course of attaining great importance, would be still more valuable if it were possible, by clinical and etiological diagnosis opportunely effected, to apply the requisite individual measures of prophylaxis and restoration.

Here it should be noted that one substance at least, namely lead, has notoriously the power of causing chronic lesions of the heart muscle; but even here its action develops so slowly that the symptoms are only produced very late, that is to say, when renal and arterial changes have occurred; and, in this case, it is impossible to control a phenomenon which most often depends on a series of organic changes which have been completed in the past.

Apart from lead, occupational pathology of the circulatory system does not depend for its existence on any specific single morbid agent, as is the case with certain diseases in regard to which prophylaxis and therapeutic treatment are so much the easier and more certain the better the determining cause is known. The factors in the causation of cardio-vascular pathology which have to be borne in mind are many and varied, and are here more than elsewhere related to the constitution of the individual, his previous state of health, conditions of work, etc. Particularly in the case of peasants, for example, sight should not be lost of the special configuration of the ground (whether in a plain or on a mountain), the state of technical development of agricultural work, etc.

As no specific causes exist, so, the lesions of the circulatory system are likewise not specific. On the other hand, there is quite an ordinary common pathology which may be due exclusively to work in itself, whilst in other cases it develops more or less rapidly under the influence of ordinary and common co-ordinated actions more or less strictly related to occupational activity.

In this category may be enumerated: cardio-vascular lesions observed in subjects suffering from occupational disease (e.g. lead poisoning, ankylostomiasis, pneumoconiosis, pulmonary emphysema among musicians who play wind instruments, etc.) and in whom the cardiac alterations are mostly (excluding: lead poisoning) only the indirect consequences of a pathology which had indeed at its outset an occupational character, but of which the cardiac troubles cannot be considered as of this nature; the alterations in the heart peculiar to certain kinds of manual work and those due to fatigue or voluntary over-exertion (excess of sport); alterations due to narcotic substances; diseases due to accidents, and to syphilis of professional origin; in so far as it affects the cardio-vascular
apparatus (Ayerza's disease is an example of this kind); heart troubles due to electricity.

As regards this last group, when the electric current is of low tension it produces an action on the cardiac muscular apparatus which brings about fibrillary contraction and this, if it is prolonged, causes death (Prevost, Battelli, d'Haluin); in these cases of essentially cardiac reaction, as soon as the heart shows signs of fibrillary contraction the arterial circulation fails, the respiratory apparatus which becomes disordered and gasping respiration precedes death.

Changes in the heart and death due to electricity belong rather to the domain of the pathology of accidents, but it is useful to recall here that clinical examination brings out in relief the great importance of constitutional differences, individual and momentary, in the reaction of the organism to electric currents.

Occupational cardio-vascular pathology ought to offer vast possibilities for prophylaxis; but, with so many varied factors at work all directed towards a common pathology, it is not possible to present a hard and fast picture. It cannot be repeated too often that industrial pathology of the cardio-vascular system is not specific in its manifestations; it is industrial in its etiology and in the manner of its development, since the occupation involved plays a part, perhaps even the major part, in its causation.

From the clinical and anatomopathological point of view, there are known myocarditis, endocarditis, aortitis, arterio-sclerosis, vascular atheromatosis, syphilis, endocarditis, arterio-renal insufficiencies, and nephropathia (certain cases of nephritis, nephrosis, nephroptosis).

First must be placed myocarditis, or rather, myocardopathias — those reactions of the cardiac muscle induced by alterations more or less extensive, at times but slightly extensive, more or less stable, which must not be overlooked, however, when it is a question of manual labour and the many mechanical actions which it involves. These lesions occur in individuals, more or less experienced in manual work, who have been subjected to extraordinary, intense and prolonged effort, and those who have been exposed to poisons and infections of an occupational or non-occupational character. But it is persons of feeble constitution or those with less organic resistance, admitted to work demanding more than an ordinary test of their powers, who are the first to fail.

In early or latent cases of this kind, adequate medical supervision may avert disagreeable occurrences. Such medical supervision is also likely to succeed in the case of individuals suffering from pronounced cardio-arterial disease; the symptoms and sufferings of such cases are considerably relieved and they may attain an output almost equal to that of healthy persons (observations during the war showed that there are cardiopathies capable of sustaining every kind of fatigue). To quote only recent writers, the working at the same time as eating; Berinson, Coombs, Cotton, Hirschberg, Mock, Moon, Phipps, Raimond, Sheppard, Stein, White, Wilson, Wolfe, who assert that occupational activity is possible for heart patients, provided they do not exert themselves unduly. Where there is good compensation these cases can be maintained in a good state of health.

A group of factors which might be classified together under the heading of "excesses" exercise, even under normal conditions, a marked repercussion on the health of the individual and his output. Among these factors: abuse of alcohol and tobacco and sexual excess; over-feeding of all kinds, as well as excess in sports, in which many workpeople now indulge. But mention should also be made of some strange combinations, such as speaking at the same time as eating; making a speech immediately after eating; excessive effort; drinking too much, even between meals or before going to bed, etc., which are in themselves capable or acting prejudicially and of upsetting still further the already eranged action of the heart. And this concomitance of causes may assume still further complication. It suffices to recall in this connection the effect upon workpeople under the influence of an industrial poison, such as lead, which affects the arteries and upsets the metabolism of uric acid; or again alcoholic absorption, which disturbs the functions of the liver and elimination of uric acid, and thus leads definitely to a diminution in the resistance of the cardio-renal system. And the same can be said in regard to nicotinic diseases, etc.

During the war "soldier's heart" was the subject of much study. Cotton, Lewis and Thiele were able to connote a group of maladies with a special symptomatology, which came on gradually or suddenly during the time of training or active service in the trenches.

The hypothesis advanced by these experts regarding the influence of
work could not be shaken by some cases which did not present case histories proving serious fatigue or strain. Cotton, Lewis and Thiele were able, from the past history of these soldiers, to discover some infectious malady which had paved the way for the appearance of "irritable heart" ("soldier's heart"), characterised by an exaggerated irritability after slight fatigue or a moderate stimulus. These phenomena are said to be sufficiently common even among civilians and represent, according to Mackenzie, an expression of general exhaustion rather than affection of the heart.

But other factors have been noted as assisting if not preceding this symptomatology: the abuse of tobacco by soldiers during the war, especially among those who had not been smokers (Galli, Romberg, Michell), the existence of a pre-basedowian state and finally a congenital predisposition among those who had not been smokers (Galli, Romberg, Michell), the existence of a pre-basedowian state and finally a congenital predisposition.

While all these excesses are capable of showing their effect on the normal individual, they are sure to react more intensely on individuals in a state of cardiac inferiority (organic inferiority, unsuitable work, excess).

This is why, from the point of view of prophylaxis and occupational hygiene, it is the duty of the medical man to try to discover any abnormal manifestations of the cardio-vascular system in an apparently healthy workman with an unfavourable previous history.

On the other hand, when examining a workman who has been ill or complains of suffering, a thorough and detailed examination should be effected with a view to furnishing as complete a diagnosis as possible. The duty of the medical man comprises points which are often less delicate, since he has to reply specifically to the following two questions:

(a) Can the worker suffering from a cardio-vascular complaint which is not acute be rehabilitated?
(b) What output can an individual affected with a cardio-vascular disease effect without prejudice to his condition?

To the first question it is now possible to answer that a cardiopath can be maintained in a state of perfect equilibrium. The reply to the second question is not so easy. The causes which habitually act on the heart directly by altering the myocardium, after a short or long period, are mainly those of a mechanical origin, acting either alone or in conjunction with other factors.

The importance of these causes is brought out by the teachings of experimental medicine, which show the relation, to a large extent, between industrial fatigue and cardio-vascular pathology:

(1) Severe fatigue causes alterations in the muscle fibres of the heart which are remediable by rest and good food, provided they have not progressed too far; in which latter case they are irreparable. The supra-renal capsules become altered similarly in severe fatigue (Cesa-Bianchi) and in this state soon cause repercussion on the blood pressure and functions of the heart.

(2) In severe fatigue there is a marked neutrophile polynucleosis, accompanied by transitory changes in the gases of the blood (excess of carbon dioxide), due to a modification of the leucocytary functions (Ciovini). The experiments of Aiello show that the leucocytosis disappears as muscular exercise proceeds and even before a state of fatigue has been reached; this leucocytosis, however, need not bear any relation to the more or less abnormal organic state produced by muscular effort, but may be regarded as a defensive reaction on the part of the organism against the changes in organic equilibrium that fatigue might bring about.

(3) During intense muscular work acetone is produced together with an increase of the antitryptic power of the serum of the blood (Preti).

(4) Periods of intense fatigue among farm labourers (e.g. harvest time), produce noticeable lowering of the cardiac force and of the blood pressure, which does not last and disappears in the weeks of relative rest that follow.

(5) Fatigued animals show an increased susceptibility to electric currents (Aiello, Pugno). The vegetative nervous system participates in the fatigue symptoms. The sympathetic cervical ganglions show subsequently fine and constant alterations following on fatigue (Aiello).

(6) During fatigue the blood ferments undergo important changes and the sedimentation time of the red blood cells is reduced (Sereni).

All this explains why fatigue effects and exhaustion are more or less recorded by an organism according to general or monovisceral conditions and so much the more so where there also exist poisoning or infections, present or past, which reinforce such effects.
Mention must also be made of some morbid accompanying conditions, the pathogenic co-operation of which explains the diversity of their symptoms. Industrial poisoning of the respiratory tract is increased when pre-existing damage has been done to the respiratory or circulatory apparatus, as the expectoratory phase in these cases is reduced; in like manner, the effects of fatigue under similar conditions exert a more serious effect on the cardiovascular apparatus. For this reason the trained medical man must not confine his action to making an accurate diagnosis of heart disease but must also so adjust the occupation, the diet and the medical treatment offered to the patient as to ensure the preservation of a state of compensatory equilibrium of the heart, with, further, a certain reserve in favour of the cardiac functions.

In studying the etiology and pathology of a disease of the heart and blood vessels, much importance must be attached to heavy and trying work on account of the sustained effort demanded. Such effort entails maladjustment as the workman advances in age and as other factors diminish the resistance of his system.

According to several authors, the effort required by certain instruments (contrabass and tenor violin) and by singing is said to cause violent haemorrhage and rupture of the pulmonary artery (Diennerbroek's case of a flute player), the condition being favoured by the bent position of the upper part of the body (contrabass, tenor violin, etc.). Recently, however, various authors have denied this source of injury as occurring for instance among singers (Thousing and Lohfeldt).

Considerable importance must be attached to the effect of those infectious diseases which cause definite change lesions in many individuals, principally of the heart muscle. The consequences of such diseases contribute their effect to that of the trying work in question which is resumed once the disease has terminated, by increasing the lesions and intensifying the sensitiveness of the myocardium to hard work. See also article "Occupational Diseases: Respiratory Apparatus", for emphysema of the heart.

Poisons such as lead, arsenic, phosphorus, etc., have a selective action on the myocardium whenever the heart is in any way damaged. Injuries, falls, etc., only set up a first slight tearing, disturbing the continuity of the endocardium, but on this site strictly limited inflammatory processes develop, which become later on the starting point of later endocardial lesions (Ranelletti).

Digestive troubles, visceral displacements, flaccidity of the left side of the diaphragm, combined with dyspeptic atony and dilatation of the stomach exercise in general a mechanical and even a toxic action on the cardiac functions and tissue.

The environment in which persons suffering from heart disease work should receive careful attention: as far as possible, they should not be exposed to abnormal conditions of atmospheric pressure (rarefied or compressed air), unduly high or low temperatures, or to abnormal conditions of the chemical constitution of the air (excess of carbonic acid gas, presence of sulphurised hydrogen, carbon monoxide, etc.) (Ferrannini).

Similarly, the position assumed at work should be chosen so as not to hinder maintenance of the circulation in a relatively stable state of equilibrium, by more or less artificial compensation.

In persons suffering for the first time from an acute infectious disease, before any obvious symptoms suggesting endocarditis had developed, the electrocardiogram showed that the heart had been affected in some way or other in 28 per cent. of these cases (Burnett and Pilz), whereas physical examination only revealed changes in 3 out of the said 28. These changes, however, were not definite in all cases and disappeared in the majority.

The following conclusion would appear to be justified: microbes and their toxins set up in the myocardium small inflammatory degenerative centres, susceptible of later growth or resulting in involution and cicatrisation; in similar manner there is reason to believe that excessive effort or the exercise required in trying work may lead to the formation of slight and very limited changes, the development of which is also favoured by a dyscrastic condition or by acidosis.

A long time ago Munzigcr and others described "peasant's heart", known under the name of "Thüiniger Weinherz", a special form of heart disease also found in other countries. Thus, for example, the condition in question is found amongst the peasants of Upper Valtelline (Italy), in Liguria, etc., who have developed and cultivated the famous vines and pastures on the steep sides of their mountains, and who have several times a day to climb up and down hundreds of steep steps roughly cut out of the rock, with heavy loads on their backs. The fate of these workers is sure; they develop diseases
of the heart at a certain age, death being accelerated by acute broncho-
neumonia or other acute condition.
All medical men who have had to treat persons who, after severe effort in sports, have suddenly shown lesions of the circulatory system with dilatation of the heart (disappearing after a week's rest and appropriate treatment), must recognise the possibility of acute myocarditis, both benign and circumscribed, occurring as the result of intense and prolonged effort followed by complex troubles of metabolism. At the clinic for industrial diseases in Milan there have been received for treatment messengers, steel forgers, porters, miners, etc., in whom pro-
longed and intense overpressure had set up cardiac changes, which, by reason of the symptoms as well as in the evolution and favourable termina-
tion, could most easily be explained as the result of myocardi
t changes. The
myocardium behaves like many other organs; improvement follows benign and circumscribed inflammatory les-
sions when the cause that has produced them has been completely and rapidly removed; this fundamental fact ought to serve as a guide to the medical man in his timely intervention (Dvon-
sto).
Histological observations, it is true, have shown the absence of lesions in the myocardium among persons showing fatigue of the heart as a result of effort (Reiche). But these researches require to be more extensively pursued, utilising the technique which modern science has made available.
The nature of cardiac affections varies according to the age of the sick person; this is confirmed by statistics of Myriam Lincoln (1924) in accordance with which the following analysis into different forms of heart trouble was obtained from 80 observed cases:

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Heart patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rheumatic</td>
</tr>
<tr>
<td>Below 20 years</td>
<td>4</td>
</tr>
<tr>
<td>20-29</td>
<td>10</td>
</tr>
<tr>
<td>30-39</td>
<td>7</td>
</tr>
<tr>
<td>40-49</td>
<td>4</td>
</tr>
<tr>
<td>50-59</td>
<td>2</td>
</tr>
<tr>
<td>60-69</td>
<td>1</td>
</tr>
<tr>
<td>Over 70</td>
<td>40</td>
</tr>
</tbody>
</table>

Statistics compiled by E. Torrentini (1926) clearly show that the frequency of cardiac trouble among workers in-
creases with age:

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Absolute value</th>
<th>Per cent.</th>
<th>According to age</th>
<th>According to sickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>On pension at 20 years</td>
<td>5</td>
<td>6.35</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>... up to 30</td>
<td>53</td>
<td>6.35</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>... 40</td>
<td>60</td>
<td>7.32</td>
<td>1.31</td>
<td></td>
</tr>
<tr>
<td>... 50</td>
<td>908</td>
<td>12.06</td>
<td>2.05</td>
<td></td>
</tr>
<tr>
<td>... 60</td>
<td>1,034</td>
<td>15.70</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td>... 70</td>
<td>5,432</td>
<td>65.75</td>
<td>77.45</td>
<td></td>
</tr>
<tr>
<td>7,014</td>
<td>—</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the statistics of the Registrar-General in England, published in his Decennial Supplement, which appeared in 1927 (for the period 1921-1923), the mortality from diseases of the circulatory system taken altogether does not appear to differ very much from the general mortality. Excep-
tion, however, must be taken to the group of unskilled workers for which the mortality figure was 1,199 as com-
pared with the standard 1,000 for all occupied males.
The extremes of the above figures are: 369, minimum for the group of game-keepers, and 2,375, maximum for the groups of tin and copper miners employed under-
ground.
The same statistics give the follow-
ing figures for valvular heart disease:

**LOWEST MORTALITY**

<table>
<thead>
<tr>
<th>Occupational group</th>
<th>Comparative mortality figures</th>
<th>Ratio mortality for all occupations = 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insurance officials</td>
<td>14.6</td>
<td>230</td>
</tr>
<tr>
<td>Gamekeepers</td>
<td>13.8</td>
<td>240</td>
</tr>
<tr>
<td>Bank officials</td>
<td>91.2</td>
<td>334</td>
</tr>
<tr>
<td>Clergy (Anglican)</td>
<td>24.8</td>
<td>391</td>
</tr>
<tr>
<td>Millers</td>
<td>24.0</td>
<td>393</td>
</tr>
<tr>
<td>Medical practitioners</td>
<td>37.8</td>
<td>438</td>
</tr>
<tr>
<td>Roman Catholic priests</td>
<td>26.9</td>
<td>472</td>
</tr>
<tr>
<td>Railway signalmen</td>
<td>29.9</td>
<td>472</td>
</tr>
<tr>
<td>Gasfitters</td>
<td>31.6</td>
<td>438</td>
</tr>
<tr>
<td>Cement workers</td>
<td>32.8</td>
<td>517</td>
</tr>
</tbody>
</table>
Arterio-sclerosis is one of the principal causes of death among diseases of the circulatory system. Of 100,812 deaths of this description (including aneurysm) among all occupied and retired males, 23,364 (23 per cent.) were due to arterio-sclerosis.

But it is always necessary with statistics as to frequency of heart disease in different occupations to interpret them with great caution. It must be remembered in particular that persons so affected try to find a trade suitable to their state of health and they take it up as soon as they have left a trade in which it is impossible for them to continue. In mortality statistics, however, the registration of death naturally only shows the last occupation. Therefore there would be an inclination to incriminate a trade which may really be reckoned amongst the least injurious to health, if statistical data, alone, are considered without discrimination. Another difficulty encountered in statistics of heart disease is that there may be united under one occupational heading very varied processes or operations differing widely in their action upon the circulatory system (Ferranini).

In practice the development towards heart affections generally occurs in the following way: a person accustomed for many years to hard work in a particular industry comes to find that he cannot perform it with the same ease as formerly; he has difficulty in climbing, in carrying weights, in running; sometimes he has difficulty in breathing after food, even when it is not in excess of what he is accustomed to; he has trouble in dressing himself rapidly, in bending to pick up an object from the ground. These movements are accompanied by an increase in the number of respirations and pulse rate. Physical examination may show hypertrophy of the heart and a murmur confirmed by a radiograph. This may be a case of incipient myocarditis or endocarditis, developing concomitantly with arterio-sclerosis extending as far as the kidneys. All this is the result of a life of intense labour, which may also have been aggravated by abuse of tobacco, alcohol, etc. This very simple picture may be further complicated by the effects of infectious diseases which have preceded it and paved the way for lesions set up by fatigue. What happens thereafter belongs to the domain of internal medicine: extension of the trouble, partial rupture, later complete, loss of compensation, degenerative changes, pseudo-anginal attacks or anginal attacks, etc.

### HIGHEST MORTALITY

<table>
<thead>
<tr>
<th>Occupational group</th>
<th>Comparative mortality figures (Total mortality for all occupations = 63.4)</th>
<th>Ratio mortality for all occupations = 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slate miners and quarryers</td>
<td>104.4</td>
<td>1.647</td>
</tr>
<tr>
<td>Wool weavers</td>
<td>105.6</td>
<td>1.686</td>
</tr>
<tr>
<td>Cotton blowroom operatives</td>
<td>107.0</td>
<td>1.727</td>
</tr>
<tr>
<td>Slaters and tilers</td>
<td>109.5</td>
<td>1.727</td>
</tr>
<tr>
<td>Cutlery grinders</td>
<td>117.4</td>
<td>1.829</td>
</tr>
<tr>
<td>Slate masons</td>
<td>126.4</td>
<td>1.994</td>
</tr>
<tr>
<td>Barmen</td>
<td>128.3</td>
<td>2.024</td>
</tr>
<tr>
<td>Cotton blowroom operatives</td>
<td>130.8</td>
<td>2.063</td>
</tr>
<tr>
<td>Cotton carders</td>
<td>137.6</td>
<td>2.170</td>
</tr>
</tbody>
</table>

### LOWEST MORTALITY

<table>
<thead>
<tr>
<th>Occupational group</th>
<th>Comparative mortality figures (Total mortality for all occupations = 63.4)</th>
<th>Ratio mortality for all occupations = 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coppersmiths</td>
<td>18.5</td>
<td>382</td>
</tr>
<tr>
<td>Cement workers</td>
<td>20.7</td>
<td>316</td>
</tr>
<tr>
<td>Wood-working foremen</td>
<td>24.1</td>
<td>367</td>
</tr>
<tr>
<td>Iron miners below ground</td>
<td>26.7</td>
<td>407</td>
</tr>
<tr>
<td>Paper mill workers</td>
<td>30.7</td>
<td>408</td>
</tr>
<tr>
<td>Farm labour</td>
<td>33.3</td>
<td>502</td>
</tr>
<tr>
<td>Gamekeepers</td>
<td>36.2</td>
<td>502</td>
</tr>
<tr>
<td>Slaters and tilers</td>
<td>37.0</td>
<td>564</td>
</tr>
<tr>
<td>Slate miners and quarryers</td>
<td>39.5</td>
<td>602</td>
</tr>
<tr>
<td>Building foremen</td>
<td>39.7</td>
<td>605</td>
</tr>
</tbody>
</table>

### HIGHEST MORTALITY

<table>
<thead>
<tr>
<th>Occupational group</th>
<th>Comparative mortality figures (Total mortality for all occupations = 63.4)</th>
<th>Ratio mortality for all occupations = 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton carders</td>
<td>125.8</td>
<td>1.589</td>
</tr>
<tr>
<td>Cellarmen</td>
<td>125.1</td>
<td>2.959</td>
</tr>
<tr>
<td>Pottery dippers, glazers, etc.</td>
<td>133.9</td>
<td>2.102</td>
</tr>
<tr>
<td>China, etc., kiln and oven men</td>
<td>139.2</td>
<td>2.192</td>
</tr>
<tr>
<td>Tin and copper miners</td>
<td>147.1</td>
<td>2.392</td>
</tr>
<tr>
<td>Hat formers, plankers, etc.</td>
<td>159.0</td>
<td>2.547</td>
</tr>
<tr>
<td>Barristers</td>
<td>164.9</td>
<td>2.514</td>
</tr>
<tr>
<td>Slate masons</td>
<td>172.3</td>
<td>2.642</td>
</tr>
<tr>
<td>Cutlery grinders</td>
<td>185.9</td>
<td>2.934</td>
</tr>
<tr>
<td>Tin and copper miners below ground</td>
<td>212.8</td>
<td>3.244</td>
</tr>
</tbody>
</table>
On the other hand the condition just described may remain stationary or improve, as the heart muscle has powers of recovery and reserves. But it is necessary to examine the workman carefully, taking all factors into consideration, and to eliminate all causes liable to influence the heart detrimentally; at first to reduce the length of the working day, at any rate for a time. In life on the land, the heart can sustain intense hard work daily for some weeks (harvest time) provided that rest periods follow (in the months during which the work diminishes and when there is a possibility of a better diet, fruit, etc.).

Attention may now be directed towards a scrutiny of the means available for making a functional diagnosis of heart cases: to certify that the heart is sound in an individual, permitting him to undergo fatiguing work, to participate in sports, etc. Such diagnosis has been considered in the past and still is considered as a rich opportunity for acquiring means of examining in detail the anatomo-physiological conditions of a heart showing evidence of deterioration.

Certain more or less complicated methods of effecting such diagnosis have been proposed, but, according to Devoto, they are not of practical use in judging of the state of the heart when it is a question of response to demands proportional to normal activity.

In fine, the questions to be answered are: how far is the heart of an individual compromised who has recovered from an infectious malady and sustained heart injury thereby? Can such an individual continue to follow an occupation involving heavy work? Can he be employed in a caisson? Can he engage in aviation?

These questions have to be answered by the methods of practising physicians, that is, by means of questions, by clinical examination and with the aid of some quite simple auxiliary methods. Among the questions which can usefully be asked are those having reference to (a) prevailing family maladies (rheumatism, occupational diseases, etc., affecting the parents); (b) personal history (previous infectious maladies); (c) particular constitutional signs in the individual (tendency to spinal curvature, whether he has outgrown his strength, etc.).

Such a procedure is so simple and natural that it is unnecessary to insist on it. In effect it is not always easy to participate in heavy work demanding participation of important groups of muscles, including the heart muscle (Pieraccini). Under these circumstances the hypertrophy is a normal one; in the other it is pathological.

Further, apparently no data exist which would justify the definite statement that fatiguing work causes pathological changes in the heart in cases where the organ was healthy on commencing the work. On the other hand, it may be affirmed that heart weakness or simply idiopathic hypertrophy can be found when the hard work has been commenced during the school age or shortly after leaving school, as well as in cases where, as has happened, the workman resumes work too soon after suffering from an infectious disease, that is before complete recovery has been effected (Brezina). Cases of idiopathic hypertrophy have been described especially by Giuffre, who has observed this condition in five out of eleven fishermen whom he examined at Sferracavallo. Mosso, Heuschen and others have noted the same phenomenon in Alpine climbers and skiers.

It is a very delicate matter to detect the fundamental cause responsible for hypertrophy or which probably gave rise to it. Similarly, it is necessary to determine in a very thorough manner whether the subjective and objective symptoms are due to lesions of the cardio-vascular system rather than to one of these following conditions which often have important repercussions upon the heart: cesophagial affections; aero-phagia, wind, adhesions, abdominal ptosis, extensive in the fibres of the myocardial vessels, if it does not constitute an absolute contra-indication, merits, at any rate in the absence of tangible signs of a heart lesion, a meticulous use of the electro-cardiograph. Indeed, workmen who have resumed their fatiguing work after having suffered from one or more infectious diseases seek medical advice some time later thereafter with abnormal heart signs: painful palpitation, cardiac hypertrophy, myocarditis, cardiac insufficiency.

An opinion on the state of the heart of an adult engaged in fatiguing work is sometimes difficult in practice. This is due to the fact that an enlarged heart, recognisable on percussion, palpitation and by radiography, is not sufficient evidence of a condition either pathological or heralding disease. Distinction must be made therefore between cardiac hypertrophy due to compensation, which is useful and indispensable for overcoming internal resistance, from that which is necessary in work demanding participation of important groups of muscles, including the heart muscle (Pieraccini). Under these circumstances the hypertrophy is a normal one; in the other it is pathological.
OCCUPATIONAL DISEASES

— 450 —

CIRCULATORY

colitis; (b) liver and kidney diseases; (c) nervous diseases.

In the meantime, some authors have suggested special methods for recording the activity of the heart muscle as a whole, without any special attention to the occupational factor, but in determining cardio-vascular pathology from an occupational point of view they are apt to supply data too late to be of practical use, since well-conceived methods of clinical research diligently pursued suffice for determining accurately the relation between the heart and the vessels on the one side and the occupation on the other, without necessitating the use of a complicated equipment. Further the so-called functional methods of diagnosis in practice meet with special difficulties for several reasons: (1) they do not eliminate the psychical factor, which plays a great part in the examination of cardiac functions; (2) their results to be significant must register a notable departure from the average, yet amongst young people very contradictory data may be found; (3) in a subject who is not highly educated, experiments of a novel kind are both frightening in themselves and almost always inconclusive.

The part played by the psychic condition becomes more important once those tested are aware that they are being submitted to fatigue tests. Besides, the eventual reaction of cardiac debility provoked is a consequence of exercises differing widely from those effected in course of ordinary work. Current experience has shown and still shows that simple and precise methods are those which help the medical man in estimating cardio-vascular conditions in a workman occupied in fatiguing tasks (Devoto). In the same way when effecting a test recourse should be had to the simplest and most natural methods — thus, the subject should be asked to climb a ladder, to deliver a message rapidly, to run quickly along a passage, hold the breath during thirty seconds after an average inhalation, to bend the hips on the legs several times and at the same time extend the arms, to get up quickly from a prone position, etc. These simple measures should not be suggested in a solemn manner but as extremely simple' things should not be suggested in a solemn manner but as extremely simple' things; in estimating cardio-vascular conditions it is more expedient to take these counts later. The test of the haemoclastic crisis can be made after a short effort or the Czermak-Wenckebach test can be applied (compression of the pneumogastric nerve in the neck) bearing in mind Hering's interpretation (eventual sclerosis of the carotid). The assertion of Eimer and other authors that auscultation of the heart has no value should be accepted with reserve.

On the other hand, attention must be paid to certain facts which seem to herald practical results: thus, for example, in a workman with a sound heart, excessive exertion causes diminution in the volume of the normal organ or increases it without any anatomical changes: on the other hand, in cases where the myocardium is altered, a dilatation takes place (Kaploun). When it is necessary in quite special cases to know an individual's capacity for resistance when called on to carry out exceptional efforts, recourse may be had to the electrocardiograph which will enable diagnosis to be made.

It can really be said that the study of the subjective condition of the workman considered in conjunction with the results of habitual observation of the physical symptoms (including a radiograph and if possible an electrocardiograph) as well as determination of the blood pressure interpreted in the light of conclusions drawn from recent and former past history constitutes the basis of the examination. With the deductions drawn from these fairly precise sources a diagnosis can be made in each case, and accurate replies can be furnished to questions put by workpeople, employers or by the conscience of the examiner himself.

So far as concerns the special case of athletes, methodical examination of blood pressure before and after the test enables an opinion to be given as to their efficiency and their training. A low maximum blood pressure at the start would appear to be an unfavourable sign (Aiello).

BLOOD VESSELS (ARTERIES, VEINS)

The pathology of the arteries is essentially that of arterio-sclerosis. Intense and continued efforts react not only on the heart but also on the arteries, which gradually suffer the condition known as arterio-sclerosis, more or less diffuse. Apart from the mechanical effect producing this condition there are effects of changes of a chemical nature brought about as a result of exaggerated physical activity (Pieraccini, Boveri, etc.); often certain
toxic substances (lead, alcohol, nicotine, coffee) exercise a preponderating or concomitant action; toxic-infectious factors arising from various acute and chronic maladies, and in particular syphilis; finally, factors of a psychological nature (intense mental work, overpressure, anxiety, worries, etc.).

The extreme consequences of diffuse arterio-sclerosis, whether associated with high blood pressure or not, are known and need not be insisted on here. The trades which require a limited and circumscribed activity but at the same time necessitate intense manual work produce arterio-sclerotic manifestations of a local nature (Baeumler, Pottain, Taisson), and along lines of hardened serpiginous arteries can be brought out clearly by radiography (Pieraccini), especially among dressers of stone, turners, shoe-makers, polishers, ironers, laundry-workers, etc. Among the last-named account should be taken of exposure to cold (Devoto).

From the examination of 500 coal miners, D. Elliot and W. Arnott Dick-son (1929) were led to the conclusion that the circulatory apparatus in this class of worker shows at all ages an extraordinary predominance of thickened arteries, limited in cases examined to the innermost layers, and that this condition was not accompanied by an increase in blood pressure, while the constant factors of importance accompanying it were: (a) inhalation of air that had undergone change as to the amount of carbon dioxide; (b) the absence of natural lighting; and finally that the high rate of mortality found among miners might be due to the frequency of arterio-sclerosis.

Aneurism is often found associated with an arterio-sclerotic condition, especially when at the same time syphilis is present or traumatism in certain predisposing personal factors. Be-nassi reported in 1925 two cases of sudden death during work from spontaneous rupture of the aorta.

Arterial resistance is increased the further the arteries are from the heart and the smaller their calibre (Haller). Consequently the aorta and especially the region of the aortic arch are the parts most exposed to dilatation, because they are the parts most directly and perpendicularly affected by the blood column.

Among peripheral arterial lesions, mention should be made of those resulting from work in compressed air (see article "Compressed Air") and in particular work with pneumatic tools (see article "Pneumatic Tools"). Some cases of writers' cramp are due to sclerosis and atheromatous degeneration of the brachial arteries (intermittent angiosclerotic dyskinesia). This is an affection resembling claudication, met with among women workers whose hands and arms are exposed to cold (Dettermann).

Functional affections of the capillary circulation have been described by Meyer-Brodantz and Wollheim (1929) among workmen employed on machines for beating hides in the leather industry. Examination of twenty work-ers showed the presence of a tendency to muscular contraction under the influence of mechanical action and of cold, similar to the affection met with in the form of "dead fingers". The authors regard this as an industrial malady due to violent and frequent vibration of the machine for beating the leather (see article "Pneumatic Tools").

Phenomena in regard to capillary circulation accompanied by a fall of blood pressure, alteration of temperature, etc., have been reported in cases of anaphylactic shock. Arduous work, finally, seems to have an influence on the blood pressure; reduced pressure has been recorded at the end of the week's work (Rogowski).

The occupational pathology of the veins is relatively simple and indeed it may be said to have lost importance since the improvement in conditions of work (shorter hours, seats provided at work, etc.). Not long ago, especially in districts where women were recruited for industrial work at an unduly early age, varicose veins of the legs were frequently met with. Evidently a prolonged standing posture predisposed these lymphatic and thin girls to venous stasis with involvement of the capillaries, sensation of painful tension in the legs, occurrence of oedema towards evening, etc. (Devoto).

Dilatation of the haemorrhoidal veins is found, especially among persons who are obliged by their work to remain seated (teachers, tailors, shoe-makers, etc.) or standing. Great importance cannot be attached, on the other hand, to work as a cause of varicocele, which is often found to be present even at the entrance examination.

Special attention must be paid to the problem of varicose veins in the legs and especially varicose ulcers of the leg 1, which both old and modern writers consider to be closely related to occupation as regards etiology. The old view of the French school which laid the blame on arthritic constitution

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1 The following notes referring to varicose ulcers of the leg are according to an original report by Prof. ULMANN, Vienna.
has now been replaced by the theory of stasis developed by Ferd. Hebra, P. G. Unna and Th. Biliroth. A prolonged standing, or a burden placed on the leg beyond the resisting capacity of the veins of the lower limbs ends by weakening the valves of the cutaneous veins first and of the muscular veins afterwards; stasis favours the engorgement of the venous ramifications deprived of such valves and brings about oedema which may or may not be accompanied by characteristic pain. The stasis is not always uniform; it generally affects both legs and brings about itching, which leads to scratching, excoriations, erosions, infection and to varied forms of eczema and moist or hyperkeratotic lichen. These manifestations are met with affecting indifferently workmen and others, but they certainly may be brought about or aggravated by certain industries. Among women, besides these general causes, pregnancy must be borne in mind.

The most important factor, however, lies in individual predisposition, often of early occurrence, and clearly noted as limited to certain families, being handed on from one generation to another. This lack of resistance capacity in the veins is still considered as a point of departure for pathological manifestations. In women the relaxation of the venous tissues during pregnancy and perhaps the effect of injurious substances arising from metabolism in the suppression of ovarian functions, increases the predisposition to slackening and dilation of the veins.

Delater and Huegel consider that these varicose conditions are a final result of disturbed endocrine action resulting from dilatation of the walls of the veins. Under the name of "varicose syndrome" G. Nobil has drawn up a table showing all the characters of the dermatoses resulting from stasis — varicose veins, oedema, haemorrhages, secondary pigmentations and ulceration.

Although the correlation of varicose or "gravitation" ulcers with many occupations has been long recognised, some authorities consider that even without the influence of such occupations it would develop in particular individuals, but it is nevertheless true that an occupation imposes a special strain on the veins and may even be held to be a cause of an eczema, an excoriation, an infection, an injury, a burn, some abnormal development of a sore after a wound, the evolution or commencement of a chronic ulcerative process, a necrosis or an ulcer, not necessarily a varicose ulcer of the leg. Without the predisposing factor, and without the presence of varicose veins, this is certainly exceptional, with a resulting tendency to scepticism in regard to the purely occupational origin of such affections.

Numerous statistics, however, prove quite certainly a markedly high incidence of ulcers of the leg in certain occupations (very high percentage among locomotive mechanics, Moscow, 1926, Memorski). The trained physician who is called as an assessor before a tribunal to determine the causation of a varicose ulcer of the leg or advanced varicose veins in the leg is bound to raise the question of the past existence of prolonged muscular effort of an occupational nature, such as would be capable of increasing any predisposition to the formation of ulcers if not to set them up of itself, or, on the other hand, the existence of a single or repeated injury of thermal or chemical origin which might start the formation of the ulcer.

This question becomes the more difficult from the point of view of legal compensation since the dividing line between an accident and an occupational disease is no longer so clear in the case under consideration as it formerly was.

For the factory surgeon or physician as opposed to the pathologist, the genesis of the lesion is more important than its form and severity (Hasselmann).

To determine the influence of an external factor favourable to the development of an ulcer is extremely difficult in the case of an ulcer in the leg. Great differences certainly exist between the venous network and the existence of varicose veins in different occupations. An occupant of a job involving arduous work, it is possible to estimate the effect of the effort on the state of the vessels and even between that of the right and left sides or vice versa, according as the person is right or left-handed. Anatomical conditions may have an unfavourable influence in the case of a worker engaged in heavy work (e.g. the length of the lower limbs, or, consequentially, on the weight of the body in the case of work done standing, there occurs dilatation of the walls of the veins, the formation of flat-foot and painful cramps). Considerable muscular effort, especially during voluntary movements, movements necessitating balancing on one foot, continual walking in the case of waiters, unilateral activity) drives the blood of the muscles into the cutaneous veins and so favours the
formation of varicosity. According to the nature of the occupation, all kinds of lesions tend where predisposition is present towards the formation of ulcers or what is still more frequent accelerate the development of such ulcers. Thus it becomes impossible, except in special cases, to distinguish between constitutional factors and accidental factors that have determined or aggravated such conditions among workpeople. A certain number of individuals may have suffered from them even before taking up work in the factory and there is scarcely sufficient justification for excluding them from work even in the case of an industry involving particular risks of injury to the feet or legs. Further, bakers, tanners, smiths, carpenters, had no relation to varicose veins because of the lack of muscular movement in the lower limbs (Nobl).

In Mongol countries, particularly among Japanese, consequent on, or even primitive sitting with crossed legs; varicose veins are comparatively rare (G. Nobl), in contrast to the Java-nese, among whom ulceration of the leg is almost a national disease (Roeg-holt).

Old and recent statistics show at first that both sexes are affected to approximately the same extent, and further that pregnancy does not have the particular influence sometimes attributed to it. Nobl found in 47,540 cases of ulcerated legs (old and recent statistics of the Prague and Vienna hospitals), 29,165 men and 18,375 women, that in 1907 the sickness insurance societies of Vienna showed 16,832 days of sickness among employees of restaurants and tramways 11.7 per cent. In addition to the constitutional and hereditary factors, account, should therefore be taken of the mechanical factor with the conclusion that both are of equal importance.

As the results of 1,984 observations on subjects between 20 and 60 years of age belonging to most varied occupations, S. Diez (1929) concludes that there is no excess of varicose veins in industries likely to create obstacles favouring stasis of the blood in the circulation of venous blood in the lower limbs.

The origin of varicose veins should be sought in constitutional, congenital or acquired factors, anatomical or functional, rather than in unfavourable conditions created by certain industris in the peripheral circulation. These occupations, and particularly sedentary occupations, may, however, aggravate a condition already established by the action of constitutional factors. According to Diez, varicose veins are not therefore an industrial disease; on the other hand, certain industries are incompatible with such a condition.

Ravogli (Cincinnati) has reported that among male workers with a high incidence for ulceration of the legs, he found 284 day labourers, 27 porters, 40 vehicle drivers, 23 cooks, 22 hairdressers and coopers and 1 colporteur.

Among 195 women, there were 117 engaged in house-work, 36 were unemployed and 27 were in charge of households.

The importance of the role played by occupation is also revealed by a statement of the number of days lost: in 1907 the sickness insurance societies of Vienna showed 16,832 days of sickness for 636 persons (357 men and 279 women); for the period 1908-1912, 70,003 days of sickness; 4,600 sick persons, of whom 784 were women, who underwent treatment of ulcers, 50 days' duration for each case (Nobl). Following the example of Vienna, Berlin and other towns have provided consultation rooms for affection of the legs, thus eliminating, to some extent, the necessity of having to lie up, loss of working time, and incapacity so frequent in the past.

At the present time even severe ulcers are cured by this treatment. It is only in the case of thrombophlebitis, progressive ulcers, loss of tone or great
irritability that it is necessary to stop work and lie up with the leg in a raised position for weeks. On the other hand, deep ulcers, which are often unrecognized, require prolonged treatment in cases of thrombophlebitis.

Some exactitude in the diagnosis of these different forms of varicose veins and ulcers is necessary to-day for practitioners in industry. Incipient ulcers should be considered and treated separately from advanced ulcers. Thanks to early intervention, capable workers with a tendency to excessive ulcers should be considered and treated separately in the practitioner's consulting room by means of the present-day methods available.

Mention should be made of certain complications, such as the flaccid, sluggish, indurated ulcer, healing with difficulty, immobility and elephantiasis of the foot, haemorrhages and rupture of varicose veins, limpethe eczema, erysipelas and other acute infections, inflammations, etc. These complications are of practical importance, especially when it is a question of ascertaining cause and effect as regards the occupation and the lesion. Pain, affected with various scars or elephantiasis showing considerable functional impotence, with a tendency to traumatic necrosis and occasional infections, should be regarded with caution from the point of view of working capacity, since it is impossible to cure such cases without resting the injured limb. The most important complication is acute and chronic eczema, whether it takes the form of a primary condition with the possibility of infection leading on to ulceration, or of a secondary nature due to ulcers and varicose veins already existent; if neglected, both cases may lead to incapacity for work and prolonged suffering involving considerable expense. Regular medical supervision will prevent the occurrence of such complications.

Ullmann, Oppenheim and Kennedy have found in addition efflorescences of "lichen ruber" occurring alongside varicose veins. Often enough cancer may occur as a complication of an ulceration of the leg and A. Jung has described recently the case of a man with two ulcers which developed into cancer.

Treatment belongs to the sphere of the medical practitioner.

Persons with cardio-vascular lesions are entitled to receive compensation for the condition as arising out of occupa-

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### Prof. L. Devoto

(Milan)

**Respiratory System**


The interchange of gases between the body and the surrounding air is effected, in the case of human beings, by the circulation of air contained in the lungs. Inhaled air always carries with it small particles of dust, especially particles of
coal, which come from the fuel used for heating and lighting. This accounts for the well-known black colouring of the lungs, which is found in autopsies on all adults who have passed their lives in large cities.

In a great many industries the workers are simultaneously affected by fumes and dust resulting from work, e.g., during the preparation of chloride of lime, the respiratory apparatus is simultaneously exposed to the action of lime dust and of chlorine. This article will be confined to the study of the effects of fumes and dusts which actually find their way into the respiratory system, since all the forms of poisoning caused by these substances, as well as the diseases brought on by infectious dusts, are dealt with in special articles.

**Sources of Danger**

**Gases.** In various industrial operations a number of gaseous products are used or liberated, which may have an injurious effect on the respiratory apparatus. Amongst others are the halogens (chlorine, bromine, iodine) and their combinations with hydrogen (hydrochloric and fluorhydric acids), sulphurised hydrogen, ammonia, chlorine of ammonia, nitric acid and the so-called “nitrous” fumes, sulphur dioxide, phosgene, acetic acid, formaldehyde, acrolein, and fumes from smoke. These same gases, as well as such intermediary products as cyanide of phosgene, fluorine of dimethylarsine and of diphenylarsine, and sulphide of dichloethylene, are chiefly met with in war gas factories.

The effects of gases are extremely complex, for not only do they act on the nervous system, the mucous membranes of the nose, the larynx, the bronchial tubes, the bronchial muscles, the alveolar epithelium and the capillaries of the lung, but all these influences react on each other. In addition, there are the modifications of the respiratory caused by chemical alterations in the blood.

All acids stimulate the respiratory centre, and thus, at the beginning of their action, increase the absorption of the poison. Even narcotic fumes, before paralysing the respiration, exercise a stimulating action on the respiratory centre. But, while the fumes irritate the mucous membranes, by stimulating the trigeminal and the sensory fibres of the pneumogastric, they produce a reflex paralysing action on the inspiration and this causes sneezing, cough, closing of the glottis and contraction of the bronchial muscles. Vomiting also belongs to these reflex phenomena which have a protective influence by diminishing the absorption of the injurious substances.

A combination of these stimulating and paralysing actions brings on the terrible dyspnoea which characterises several of the acute poisonings — for example, poisoning by hydrocyanic acid — which persists up to the moment of loss of consciousness.

If such narcotic gases as carbon dioxide, protoxyde of nitrogen, ethylene or acetylene are mixed with gases which irritate the mucous membranes, the protective reflexes which paralyse inspiration are further depressed. Ammonia, by its liposoluble action, has a narcotic effect, and this results not only in increasing the danger from toxic gases, but it also favours a long period of latency with no sign of ill-health until the appearance of the symptoms.

The action on the capillaries of the lung is chiefly demonstrated, in a good many cases, by the appearance of pulmonary oedema, caused, for example, by ammonia, or of a severe hyperaemia of the lungs, accompanied by capillary haemorrhage, such as components of arsenic set up.

These primary lesions are followed by secondary foci of broncho-pneumonic inflammation, and this inflammation does not, as a rule, manifest itself until after an interval of apparent health. This period of latency is very characteristic, lasting, as a rule, a few hours, and even, though rarely, some days. A man who has been working in an atmosphere containing such dangerous fumes as nitrous fumes, without feeling any ill-effect beyond sneezing and coughing fits, goes home as usual, has his supper and goes to bed without feeling ill in any way. During the night or in the morning, he is suddenly seized with faintness, dyspnoea, and cough, accompanied with abundant expectoration of blood-stained and muco-purulent discharge, indicative of pulmonary oedema. This acute attack may develop rapidly and either end fatally, or pass off. But even in the case of a recovery, chronic inflammatory results are very often left behind, localised to the bronchi, or to parts of the lung weakened by previous illnesses. In obliterating bronchitis may then be observed, or a chronic pneumonia, or a pulmonary induration, or, finally, a vicarious emphysema in parts of the lung which, up to that time, have been unaffected.

**Dust.** Whereas the physical and chemical laws which control gases are accurately known, the physical properties of the various kinds of dust
which constitute industrial dust are far from being defined, for they have only recently been studied. Molecular and capillary phenomena assume the greatest importance when dealing with small particles; on the other hand, these phenomena are of minor import when the mechanical laws governing solid bodies of large dimensions are in action. It is a recognised fact that the former of these are charged with electricity, that they are surrounded with minute atmospheres of condensed gases which adhere closely to them; that numerous substances are hydrophile, attracting large quantities of water, whereas others are hydrophobe, rejecting every trace of water. Various substances, although they are hydrophobe, absorb liquid carbohydrates and fatty oils (general lyophilia); thus, charcoal and carbonate of lime are hydrophobe, and amorphous silicates and humic acids are, intensely hydrophile. By treating soot with benzol it becomes hydrophile, and, on the contrary, if silicates are heated they become crystalline and lose most of their hydrophile property. Silicates can also be made hydrophobe by being thoroughly mixed with very finely powdered charcoal.

As regards inhalation, importance need only be attached to the dust which remains suspended in the air.

The quantity of this dust depends: (1) on the size of the particles, their specific weight, the shape of their surfaces, and their hydrophilia; (2) on their electrical state; (3) on the rapidity of air currents during work; and (4) on the composition of the air, especially with regard to the degree of humidity of the air and the presence of electric currents.

The amount of water held by dust depends, in the main, on its chemical constitution; but the shape of the particles also makes a difference, irregular and concave surfaces attracting more moisture than a convex surface. It is impossible to discern under the microscope whether the particles of a particular kind of dust are crystalline or amorphous; it is a case of internal structure, which can only be elucidated by a radio-spectroscopic examination.

The local and chemical action of dust, as well as its general toxic and immunising action, depends in the first place on its solubility in the fluids of the body. The smaller the particles are, the greater is their solubility and their power of reacting chemically. Further, their solubility is much influenced by the presence of other substances. Thus silicic acid (SiO₂) is soluble in water in the proportion of 1 : 10,000; this solubility is much increased by oxygen, carbon dioxides, alcalis, organic substances and humic acid. Among the natural ores of silicic acid, quartz is the most difficult to modify and opal is the easiest.

The absorbent action of dust must be recognised, as well as its purely chemical action. When a hydrophile dust — e.g. amorphous silicate, which is intensely hydrophile — absorbs water from the tissues of the respiratory organs, it causes a local necrosis. In the same way, serious consequences may result when substances that are important to life are extracted from protoplasm by lyophilia.

Then again, particles of dust may convey irritant and toxic substances in a gaseous or liquid form, these substances adhering to the particles and penetrating with them into the tissues and causing chemico-tactical actions, necrosis, inflammation and allergic phenomena.

In comparison with these fundamental physico-chemical and biological actions of dust, the lesions caused by certain sharp-edged particles seem of quite secondary importance. And yet, in the past, it was believed that these sharp-edged particles caused all the trouble.

See also articles "Stone Industry", "Dusts, Fumes and Smoke" and "Tuberculosis and Silicosis".

Pathology

The Upper Respiratory Tracts

For occupational affections of the nose and larynx see article "Occupational Diseases: Ear, Throat and Nose".

The affections of the bronchi and of the lungs cannot be studied on pathological-anatomical lines, for the typical forms — bronchitis, lobular pneumonia, lobar pneumonia, pleurisy and emphysema — may be found in the same patient, and may even co-exist with tuberculosis. Therefore, there shall be dealt with here the syndromes and symptoms, which are most important from a practical point of view, without trying to carry out a strictly systematic study of the whole.

Occasional emphysema is found in occupations: (a) which are carried on in the open air, the workers being exposed to all weathers; in these cases there is found a succession of relapses after bronchitis or chronic bronchitis, e.g. among foresters and gardeners; (b) occupations in which dust is raised, even though these occupations do not
bring about pneumoconiosis, as the result of chronic bronchitis or relapses after bronchitis, as for example among scavengers, and those who sell and handle scraps of cloth and rags, rag-pickers, and workers in factories making up jute sacks for millers and bakers; (3) in which occupational asthma are observed, with frequent crises, developing into a permanent condition of asthmatic, pulmonary disension; and (d) which expose the workers to the inhalation of irritant gases and dust. It is then a complication of an obliterating bronchitis, the emphysema affecting the parts of the lung untouched by fibrosis.

In all the cases there is evidence of the "emphysematous heart", characterised by definite dilatation and thickening of the walls of the right ventricle. In addition to the clinical picture of the pulmonary lesion, there is gradually seen to develop the clinical picture of a fatal cardiac disorder, with serious dyspnoea, cyanosis and dropsy.

Laennec's theory, which attributes emphysema to the use of wind instruments, has not been confirmed by recent research. As a matter of fact cases of emphysema have not been proved to be especially numerous among professional musicians and glass blowers.

A typical occupational disease is the pneumonia which attacks workers who handle basic slag (see that article) as well as farm labourers who scatter it on the fields. Bacteriological examination has indicated the presence of the diplococcus discovered by Fraenkel-Weichselbaum.

Cases of acute lobar pneumonia are also numerous among miners and crushers of limonite (Fe₂(OH)₃) ferric hydrate). The acute lobar form is generally caused by inhaling irritant fumes. Acute and chronic cases of catarrhal pneumonia are frequent as complications of pneumoconiosis, in which the lesion, especially in the case of miners, often turns to induration and to the closing of the lymphatic passages, impeding the reabsorption of the exudations of the alveoli.

Various writers have attributed primary tumours of the bronchi and of the lungs to the inhalation of dust. Certainly "Schneeberg" disease — pulmonary cancer from which the workers in the cobalt mines of Saxony suffer (see article "Cobalt") — must be reckoned as an occupational disease, although the etiology is not yet clearly established. In the United States of America it appears that cases of carcinoma of the lung have been observed among petrol refiners, and that this resembles the cancer of the skin caused by paraffin.

Pulmonary haemorrhage may occur in extremely varied microchemical pneumoconiosis; the bleeding is of broncho-pneumonic source, and also comes from bronchiectasis, from cavities or from a blood vessel perforated by a pulmonary calculus. Of course haemoptyses may also be due to a tuberculous complication. In the case of stonecutters suffering from pneumoconiosis and tuberculosis, blood-splitting is more often found when the stones cut are hard. Fatal haemoptyses have been observed after the rupture of a lymphatic anthracotic gland, simultaneously into the left bronchus and into the aorta or else into a bronchus and a pulmonary artery.

**Diseases due to dust.** — The best classification — according to Sternberg — of the effects of dust is as follows: diseases due to: (a) an allergic action, affecting the organism, causing asthma; (b) local chromatism from soot or tobacco; (c) a local microchemical reaction, as in silicosis, chalciosis and pneumoconiosis in the strict sense of the term; (d) a local colloidal reaction, as in amylosis of the bronchi; and (e) infections, such as anthrax, tuberculosis, pneumonia, pneumomycosis and psittacosis (?).

Further research is necessary before it is certain how far occupational dust can activate an infection or prevent it, or act as an agent in the development of a carcinoma.

There may be provisionally classed as anaphylactic or allergic asthma various pneumoconiosis, some of which are well recognised, whereas others have as yet been but little studied. They are accompanied by pruriginous forms of dermatosis, described, partly, as distinct diseases of the skin.

The problem of occupational asthma is the same as that of occupational anaphylaxis. 1

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1 At the outset the term used was "pneumoconiosis" (Zenker, 1866).
In many of the cases the occupational character of the disease is clearly defined. The anaphylaxis is caused by the pollen of gramminaceous plants, dust from threshing oats, from hackling hemp and flax, from jute or cotton when opening the bales, or from flour, causing millers' and bakers' asthma.

Cases of asthma of the same variety have been observed in chemists and upholsterers, caused by such chemical products as aspirin, arszenobenzoles, ipecacuanha or lead, as well as in persons who come in contact with dust of animal origin, such as feathers, down and animal scales and hairs. In one case the asthma was caused by sepia bone reduced to powder for preparing the mould into which the goldsmith pours the molten gold (Ancona).

In the case of furriers who use "ursol", asthmatic attacks as a rule occur only in those who prepare or handle black furs, after several years of work, during which they may have experienced no ill-effects. Simultaneously or independently of the asthma, cutaneous lesions may make their appearance — urticaria, acute and chronic eczema, and erysipeloid forms, which have also been found in persons who wear furs dyed with "ursol" (see article "Paraphenylendiamine").

Cases of asthma have also been observed in florists, horticulturists and fruit pickers; they may also be accompanied by pruriginous dermatitis, and these cases are based on allergy acquired by the inhalation of vegetable dust, which often contains an acarus — the pediculoid ventricosus, its secretions and excretions. This acarus lives in parasite form on the larvae of certain insects (Sitotroga cerealella, Tinea granella, etc.), which are themselves parasites on cereals. (See also article "Flour Mills").

Bridge in 1926 drew attention to cases of coughing among workmen in malt-houses, which were attributed to the presence in the malt dust of mycella and spores of Rhizopus nigricans.

Fits of coughing came on after work, and were accompanied by a sensation of constriction in the thorax, and by abundant expectoration in the morning.

Silk-spinners' asthma, caused by handling silkworms' cocoons (Bombyx mori) is accompanied by inflammation of the eyes and a pruriginous dermatitis (mal des bassines) (see article "Silk").

As is well known, it is a question of proteins that are not completely homogeneous nor heterogeneous; they act on persons who are predisposed; and successive introductions of these proteins start the anaphylactic attack.

This predisposition is facilitated by a thymic, thymolymphatic or arthritic constitution; it consists essentially of a feeble colloidal equilibrium, known as Widal's colloid diathesis. Here, under the stimulation caused by minute quantities of the substance which has become sensitised or anaphylactised, an instantaneous change in the physical and electrical arrangement of the protoplasmic colloids takes place.

Among the pneumomyceses may be quoted the cases described in 1927 by Nussbaum and Benedikt of tumours of the lungs of occupational origin due to a penicillium.

Kovacs, of Budapest, in 1930 reported a special disease of the respiratory apparatus in workers engaged in gathering red pepper (paprika). The symptoms resembled those of tuberculosis; radiography showed a picture of diffuse broncho-alveolitis. There has also been noted bronchiectasis, at times very serious, as well as pleural lesions. Examination of the sputum is essential for differential diagnosis. The disease was at first attributed to dust raised by manipulation of the product in gathering it; but since the disease did not occur amongst workers handling the product during the processes of sorting and packing, etc., it is considered that the bronchial lesion is due to the fine spores of the parasitic moulds on the plant.

In the pneumoconiosis caused by soot, which is found amongst coal-miners, chimney sweeps and stokers on trains, the lungs are very black but are free from sclerosis. In the pneumoconiosis due to wood charcoal (Traube) the lungs are not thickened, which is also the case with coal-miners' lungs when the seams do not penetrate hard rock. Experiments on animals have given the same results. So it seems that it may be concluded that coal alone cannot cause pulmonary fibrosis. Arnold has described these disorders under the name of "anthracosis simplex"; pneumoconiosis caused by tobacco can probably be grouped under the same heading. A red coloration of the lung with silicotic fibrosis is found among men who work on haematite, and a green coloration among men who work on steatite. Siderosis, that is black or red pneumoconiosis, due to iron, discussed in the past, as well as pneumoconiosis due to ultramarine, are only rarely seen now, owing to the improvements brought about in industrial processes. These diseases were, in fact, silicosis.
Diffuse fibrosis of the lung, caused by continuous inhalation of dust, comes under the term "pneumoconiosis". According to Devoto, all pulmonary diseases due to dust come under the term "pneumoconiosis" and, setting aside the anatomo-pathological conception or an anatomo-pathological analogy, there must be included, according to more modern interpretation, bronchitis, peribronchitis, the so-called asthmatic disorders of occupational origin, pulmonary fibrosis, and, lastly, pulmonary emphysema, chronic bronchial pneumonia, the changes caused by dusts, and such forms of tuberculosis as miners' phthisis and bakers' phthisis, even where dust alone is not responsible, but only so in combination with other factors.

In the pure chalicosis that affects stoncutters, cement-makers and potters, the lung is thick and heavy; the pleura is thickened and of grey colour; it sometimes adheres to the costal pleura and its free parts are marked with little compact nodules the size of a pinhead, surrounded by numerous little pigmented zones of a dark colour. The pulmonary tissue is sprinkled with little compact nodules and with large, hard, confluent nodules. Isolated nodules, consisting of bundles of connective tissue fibres, concentric or placed spirally, sometimes in hyaline degeneration, are only slightly vascularised. The outside layers are strongly pigmented with coal, coming sometimes from heating and lighting, and sometimes inhaled in industry, at the same time as stone dust. The structure of the nodules is analogous to that of cheloids on the skin. The part of the lung which is not affected by fibrosis is generally emphysematous.

In continental Europe stonecutters' pneumoconiosis has become somewhat rare, for, in monumental building, freestone is being increasingly replaced by artificial stone.

Indurative anthracosis — a form of chalicosis complicated with anthracosis — is very widespread, especially among ironfounders, who inhale dust from stone and graphite during the preparation and demolition of moulds, as likewise among miners. In slight cases the lungs exhibit black compact bands and spots; in more serious forms, the whole lung is blue-black or intensely black and hard, sometimes with cavities which are probably due to the necrosis of fibrous tissue, but perhaps also to suppuriation from bronchiectases. The combination of pneumoconiosis with tuberculosis is very common, and highly competent specialists are inclined to think that pneumoconiosis, especially among miners, is generally the result of the combined effect of dust and a tuberculous infection. It is at any rate certain that in particular cases of anthracosis with cavities the most minute microscopic examination has not revealed any tuberculous lesions.

It is very probable that "chalicosis" is only another name for silicosis, and that pulmonary fibrosis is caused by inhaled silica dust, which originates either from natural ores or from such artificial articles as glass and china, or even from coal, of which silica in the form of sand may be a constituent.

Dust is carried into the alveoli of the lungs by the force of the inspiration, whence it is removed into the lymph channels by phagocytosis.

Dust found in expectoration is either found in the free state or encased in the cells. If the inhalation of dust is stopped for prolonged periods, it may be largely eliminated from the lung and specially localised in the lymphatic glands. But the fibrosis remains.

The clinical picture of pneumoconiosis is not clearly defined. Subjective disorders, as a rule, only appear when there are complications, after a chill or an accident, in the course of acute bronchitis or of an acute crisis in chronic tuberculosis. Devoto and his followers have emphasised the frequency of latent pulmonary lesions caused by dust. This latency does not signify that there is still functional or organic integrity of the pulmonary tissue, for this integrity in reality no longer exists, or rather, one should say, it is only present in normal conditions of health, as a true and typical cause of lessened resistance when any intercurrent pulmonary affection, such as pneumonia, occurs. Diminution in resistance of the pulmonary tissue invaded by dust is a real fact, and not an abstract conception of a functional nature. In the first phase the respiratory activity is affected; in the second, the cardiac functions. Dyspnoea is the chief symptom. Yet the workers retain their capacity for work, and only experience difficulty in breathing when their work requires great exertion. After a certain lapse of time a dry, hacking cough appears, with pains in the chest and limbs, slight haemoptysis and a rise of temperature. The objective symptoms are those of emphysema; there is not, as a rule, any decided dullness. Bäumler's sign of a narrow zone of dullness on the left sternal edge is not often found. As
the case progresses, symptoms of chronic bronchitis become predominant, and finally those of cardiac impairment or of tuberculosis. Hoarseness is due to laryngitis or to paralysis of the left recurrent laryngeal nerve, due to pressure from lymphatic nodules. The onset of serious lesions requires, on an average, an "effective period" of ten years.

The radiological picture is not an expression of the dust deposit, but of fibrosis. In the early stages of the illness an accentuation of the hilum shadow is observable, and a very slight haziness in the peripheral part of the pulmonary area which is normally clear. The pattern of the hilum zone becomes more linear, and divides up into segments as the illness develops. The symmetry of the hilum shadow is often compared with the picture of a butterfly. Little patches of shadow scattered all over the pulmonary area look like a picture of a "snowstorm", with radial bands across. The apices, as well as the lower lateral parts of the lungs generally remain free (see fig. 51).

Heavy shadows may be observed, as well as shaded patches in the form of large nodules. There is no completely characteristic radiographic picture.

Dust from iron, silica and coal throw particularly pronounced and characteristic radiological shadows. In pure siderosis the lung is riddled with in-

numerable little patches as small as millet seeds, but these are clearly distinguishable from tuberculosis and carcinomatosis by their far greater density, and by their clearly defined outline (Schaab).

Most of the men who worked at sand-blasting, i.e. cleaning steel castings by means of a sand jet, prior to the use of up-to-date apparatus used to present a serious condition with fatal issue. But in such cases, the clinical symptoms are now greatly reduced, for in the first period all are agreed in recognizing simple laboured breathing; in the second period a desquamative catarrh with dyspnoea; and in the third period a pseudo-emphysematous condition with infiltration, fibrosis and mucopurulent expectoration (Denet-Kravitz).

A case of pulmonary siderosis was described by Rist in 1923 as affecting a workman who had worked all his life in metallurgy, exposed to the inhalation of iron dust. He suffered from pulmonary fibrosis, without emphysema, and without any pulmonary lesion in the parenchymatous focus; he had only an accentuation of the hilum shadows. Breathing was permanently quickened, and vital capacity was reduced; basal metabolism was normal, but a moderate degree of cyanosis was present with a slight increase in red blood cells. Five years after giving up his occupation the expectoration still gave iron reactions (1.5 mg. of iron per 100 grm. of expectoration), but contained no bacilli.

As regards pulmonary fibrosis caused by asbestos (see that article) mention will here be confined to pointing out that one case of asbestosis was reported by Fahr, of Hamburg, in 1914. It was the case of a workman who died from chronic pneumonia, in whose pulmonary tissue microscopic examination revealed the presence of numerous crystals which were held to be asbestos crystals. A similar case had been reported in 1906 by Marchand and Riesel, but they were doubtful as to whether what they found was not the residue of haemoglobin.

In Great Britain, a great deal has been written on the subject. The first fatal case of asbestosis was described by Montagu Murray in 1906. The man referred to died in 1900, and Murray remarked, in his report, that during the next seven years he had never come across another case. Eighteen years later, in 1924, W. E. Cooke described another case, the symptom findings of which he reported in 1927, and announced the discovery of "curious bodies" which he had detected after examining the lung micro-
were described in detail by Stuart Macdonald in 1927. Anatomopathological study enabled him not only to detect an extensive fibrosis of the lungs, but also changes due to pulmonary tuberculosis. The co-existence of these lesions raised the question as to whether the fibrosis was a result of the inhalation of asbestos dust, or partly a reaction from the tuberculous infection. In 1928, Macgregor, of Glasgow, drew attention to an asbestos worker being treated for pulmonary tuberculosis. An inquiry was instituted with the object of studying the effect of his occupation on the illness. A certain number of asbestos workers were selected and examined, both clinically and radiologically; subsequently the enquiry was extended to the whole of the staff, attention being paid to the various processes of the work. Meanwhile, the death of an asbestos worker was reported, and the autopsy revealed extensive fibrosis of the lungs, and no tuberculosis. The diagnosis disclosed again the "curious bodies" of Cooke. Since then I. M. D. Grieve has carefully observed a group of asbestos workers. In 1928 two other fatal cases were reported, one of which was that of a native working in an asbestos mine in Southern Rhodesia. According to Stewart, of Leeds, and A. C. Haddow, the "curious bodies" referred to by Cooke can be found in the fluid removed by puncture in the expectoration, and, after death, in the pulmonary juice.

In 1927, Oliver, Cooke and Stuart Macdonald described a case of asbestosis; Oliver and Haddow another case; and in 1928 F. W. Simson, of Johannesburg, observed four cases among native workers of Southern Rhodesia. Mavrogordato's experimental research has emphasised the fact of the presence in the lungs of golden-yellow coloured bodies, similar to those found in the lungs of persons who have died from asbestosis. The opinion is that these bodies are fibres of asbestos that have become altered.

In 1929 several other reports were read at a meeting of the British Medical Association at Manchester, as well as other results obtained from the examination of asbestos workers. W. B. Wood carried out a special radiological examination of fifteen workers; S. R. Glyne investigated the nature of the "curious bodies", which he judges to be asbestos fibres, round which a substance has been deposited — probably blood pigment.

An enquiry on the incidence of asbestosis was published in 1930 by the English Factory Medical Inspection Department. Out of 363 workers who had been in the asbestos industry for some time, and were medically examined, 105 were suffering from asbestosis (Merewether and Price). The clinical findings and radiographical appearances of these men were described in 1930 by Merewether, who stresses the extensive impairment caused in the lungs, leading up to a fatal issue, and the presence of fine generalised X-ray shadows over both lungs. But of 30 asbestos workers examined in 1908 by Scarpa, 29 were suffering from pulmonary tuberculosis and died in the course of the twelve months which followed the first visit made by the writer.

For details as to fibrosis caused by talc, see article "Talc.

The diagnosis of pneumoconiosis is based on the nature of the occupation, the duration of the illness, the subjective symptoms, the clinical examination and especially on the radiographic picture. It is fairly easy to make a differential diagnosis from emphysema, pleural thickening, pulmonary echinocosis, diseases of the heart or aneurism; but it is more difficult to differentiate between this and pulmonary carcinoma, actinomycosis, aspergillosis, penicilliosis, pulmonary syphilis and, particularly tuberculosis. This is often only possible after long observation and frequent examination of expectoration. In these days it is important to look for silica in the expectoration (Campbell). This is easy to understand, for tuberculosis is not only a complication of pneumoconiosis, but, in the miners' occupation, it is quite accurate to speak of a definite form of tuberculo-silicosis or silico-tuberculosis (Watkins-Pitchford). (See article "Tuberculosis and Silicosis").

Statistics

While respiratory diseases do not always constitute occupational diseases in the strict sense of the word, they figure among the pathological affections which cause the most considerable loss of working days. Thus, in the United States, according to the returns of thirty-five sickness insurance societies, comprising about 100,000 persons, 47 per cent. of all the diseases for which sick pay was accorded from 1921 to 1926 were due to respiratory affections. It should also be noted that it is the more serious affections which are especially concerned, the societies only accord payment when the disease has caused absence from work for eight days or over.

In a large American electric power and light company, about three out of six days lost yearly by the personnel on
account of disease were due to respiratory affections. On the clinical form
being investigated, it showed that 70 per cent. of the absences were due to what
is commonly called a cold, which caused incapacity for work in 4 out of 10 men,
and 7 out of 10 women yearly. The incidence of such other respiratory diseases
as were noted to occur with a definite frequency, like influenza, tonsillitis and
throat affections, varied according to season, with a maximum about the month of
February and a minimum about the middle of summer. Incapacity for work for
eight days or more among a group of workers of the company in question for
the period 1921-1926 gave the

...persons of all occupations compared with the general morbidity and mortality rates
(given per 100,000) are as follows:

<table>
<thead>
<tr>
<th>Age period</th>
<th>General morbidity rate</th>
<th>General mortality rate</th>
<th>Morbidity from respiratory diseases</th>
<th>Mortality from respiratory diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ages</td>
<td>39,553</td>
<td>765</td>
<td>5,639</td>
<td>15t</td>
</tr>
<tr>
<td>15 to 24 years</td>
<td>38,579</td>
<td>441</td>
<td>4,888</td>
<td>63</td>
</tr>
<tr>
<td>35 to 54</td>
<td>44,373</td>
<td>1,198</td>
<td>6,587</td>
<td>241</td>
</tr>
<tr>
<td>55 to 74</td>
<td>59,063</td>
<td>3,031</td>
<td>12,470</td>
<td>1,055</td>
</tr>
</tbody>
</table>

As regards silicosis from respiratory diseases, according to the *Decennial
Supplement* of the English Registrar General for the period 1912-1923, it seems
that the mortality is closely associated with the social condition, and that it
depends on whether respiratory diseases include tuberculosis or not. The table
reproduced below in two parts, A and B, shows the occupational groups with the
lowest and highest rates of mortality from respiratory diseases:

### A. OCCUPATIONS WITH LOWEST MORTALITY

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Figure of comparative mortality</th>
<th>Ratio (all occupations = 1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamekeepers</td>
<td>42.7</td>
<td>281</td>
</tr>
<tr>
<td>Woodsmen</td>
<td>42.3</td>
<td>265</td>
</tr>
<tr>
<td>Signalmen</td>
<td>58.4</td>
<td>372</td>
</tr>
<tr>
<td>Nonconformist ministers</td>
<td>60.5</td>
<td>396</td>
</tr>
<tr>
<td>Farm labour</td>
<td>62.3</td>
<td>418</td>
</tr>
<tr>
<td>Anglican clergy</td>
<td>62.3</td>
<td>415</td>
</tr>
<tr>
<td>Insurance officials</td>
<td>66.3</td>
<td>437</td>
</tr>
<tr>
<td>Watchmakers</td>
<td>67.6</td>
<td>466</td>
</tr>
<tr>
<td>Railway officials</td>
<td>69.9</td>
<td>461</td>
</tr>
<tr>
<td>Teachers (exclusive of music teachers)</td>
<td>71.0</td>
<td>469</td>
</tr>
</tbody>
</table>

When examined separately for the various forms of disease, the English figures
give in the following tables (I, II and III) proportionate figures for mortality due to bronchitis, pneumonia and chronic interstitial pneumonia, which last heading includes the various forms of fibroid phthisis, fibrosis of the lung, silicosis and miners' phthisis, but excludes pulmonary tuberculosis.

### B. OCCUPATIONS WITH HIGHEST MORTALITY

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Figure of comparative mortality</th>
<th>Ratio (all occupations = 1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costermongers</td>
<td>331.6</td>
<td>2,185</td>
</tr>
<tr>
<td>Stevedores</td>
<td>345.4</td>
<td>2,326</td>
</tr>
<tr>
<td>Cotton blowroom operatives</td>
<td>368.9</td>
<td>2,432</td>
</tr>
<tr>
<td>Metal grinders</td>
<td>373.8</td>
<td>2,457</td>
</tr>
<tr>
<td>Potters</td>
<td>433.3</td>
<td>2,506</td>
</tr>
<tr>
<td>Cotton strippers and grinders</td>
<td>343.3</td>
<td>2,556</td>
</tr>
<tr>
<td>China klin and oven men</td>
<td>445.3</td>
<td>2,633</td>
</tr>
<tr>
<td>Tin and copper miners</td>
<td>659.6</td>
<td>2,648</td>
</tr>
<tr>
<td>Cuttery grinders</td>
<td>666.6</td>
<td>2,661</td>
</tr>
<tr>
<td>Workers underground in tin and copper mines</td>
<td>960.1</td>
<td>6,399</td>
</tr>
</tbody>
</table>

As regards silicosis, see articles "Silicosis-Tuberculosis" and "Gold Mines". It is, however, interesting to mention here that whereas in 1915, out of 3,136 gold-
minters of the Transvaal, 32 per cent. were affected with pneumoconiosis, a systematic medical examination of white workers — organised in 1916 — has disclosed a percentage of 5.7 in 1916-1917, of 4.65 in 1917-1918, and of 4.6 in 1918-1919.
The percentage after the new laws had been put in force:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Figure of comparative mortality</th>
<th>Ratio (all occupations = 1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roman Catholic priests</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Barristers</td>
<td>6.2</td>
<td>125</td>
</tr>
<tr>
<td>Anglican clergy</td>
<td>6.8</td>
<td>137</td>
</tr>
<tr>
<td>Nonconformist ministers</td>
<td>7.3</td>
<td>151</td>
</tr>
<tr>
<td>Bank officials</td>
<td>9.0</td>
<td>181</td>
</tr>
<tr>
<td>Civil engineers</td>
<td>9.2</td>
<td>183</td>
</tr>
<tr>
<td>Woodmen</td>
<td>9.8</td>
<td>198</td>
</tr>
<tr>
<td>Insurance officials</td>
<td>10.9</td>
<td>229</td>
</tr>
<tr>
<td>Copper smiths</td>
<td>11.0</td>
<td>230</td>
</tr>
<tr>
<td>Farmers</td>
<td>11.4</td>
<td>236</td>
</tr>
</tbody>
</table>

I. — BRONCHITIS

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Figure of comparative mortality</th>
<th>Ratio (all occupations = 1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton blowroom operatives</td>
<td>149.8</td>
<td>3,200</td>
</tr>
<tr>
<td>Metal grinders</td>
<td>156.5</td>
<td>3,155</td>
</tr>
<tr>
<td>Glass blowers and finishers</td>
<td>159.6</td>
<td>3,215</td>
</tr>
<tr>
<td>File cutters</td>
<td>163.6</td>
<td>3,098</td>
</tr>
<tr>
<td>Tin and copper miners</td>
<td>192.8</td>
<td>3,587</td>
</tr>
<tr>
<td>China kip and oven men</td>
<td>242.8</td>
<td>4,805</td>
</tr>
<tr>
<td>Workers in tin and copper mines</td>
<td>248.2</td>
<td>5,004</td>
</tr>
<tr>
<td>Potters</td>
<td>260.6</td>
<td>5,435</td>
</tr>
<tr>
<td>Cotton strippers and grinders</td>
<td>276.7</td>
<td>5,579</td>
</tr>
<tr>
<td>Cutlery grinders</td>
<td>361.2</td>
<td>7,382</td>
</tr>
</tbody>
</table>

II. — PNEUMONIA

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Figure of comparative mortality</th>
<th>Ratio (all occupations = 1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamekeepers</td>
<td>13.4</td>
<td>157</td>
</tr>
<tr>
<td>Woodmen</td>
<td>37.2</td>
<td>390</td>
</tr>
<tr>
<td>Railway signalmen</td>
<td>30.4</td>
<td>357</td>
</tr>
<tr>
<td>Nonconformist ministers</td>
<td>33.8</td>
<td>421</td>
</tr>
<tr>
<td>Brewers</td>
<td>37.9</td>
<td>440</td>
</tr>
<tr>
<td>Slate miners</td>
<td>38.4</td>
<td>451</td>
</tr>
<tr>
<td>Watchmakers</td>
<td>39.0</td>
<td>438</td>
</tr>
<tr>
<td>Wool weavers</td>
<td>40.1</td>
<td>471</td>
</tr>
<tr>
<td>Railway officials</td>
<td>44.4</td>
<td>522</td>
</tr>
<tr>
<td>Gardeners</td>
<td>44.9</td>
<td>528</td>
</tr>
<tr>
<td>Costermongers</td>
<td>168.4</td>
<td>1,679</td>
</tr>
<tr>
<td>Other dock labourers</td>
<td>170.6</td>
<td>1,085</td>
</tr>
<tr>
<td>Metal polishers</td>
<td>172.4</td>
<td>9,006</td>
</tr>
<tr>
<td>Puddlers</td>
<td>173.5</td>
<td>6,083</td>
</tr>
<tr>
<td>Cotton carders</td>
<td>185.6</td>
<td>2,181</td>
</tr>
<tr>
<td>Iron foundry labourers</td>
<td>193.2</td>
<td>2,770</td>
</tr>
<tr>
<td>Cotton blowroom operatives</td>
<td>193.6</td>
<td>2,790</td>
</tr>
<tr>
<td>Stevedores</td>
<td>207.1</td>
<td>2,434</td>
</tr>
<tr>
<td>Cutlery grinders</td>
<td>207.6</td>
<td>2,449</td>
</tr>
<tr>
<td>Brassfoundry labourers</td>
<td>211.1</td>
<td>2,492</td>
</tr>
</tbody>
</table>

III. — CHRONIC INTERSTITIAL PNEUMONIA

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Figure of comparative mortality</th>
<th>Ratio (all occupations = 1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total occupied and retired</td>
<td>1.34</td>
<td>1,060</td>
</tr>
<tr>
<td>Coal miners, hewers and getters</td>
<td>3.34</td>
<td>2,493</td>
</tr>
<tr>
<td>Do., making and repairing roads</td>
<td>5.87</td>
<td>4,381</td>
</tr>
<tr>
<td>Do., others below ground</td>
<td>1.45</td>
<td>1,082</td>
</tr>
<tr>
<td>Do., above ground</td>
<td>1.35</td>
<td>1,173</td>
</tr>
<tr>
<td>Iron miners</td>
<td>17.37</td>
<td>13,410</td>
</tr>
<tr>
<td>Tin and copper miners</td>
<td>360.91</td>
<td>3,000,000</td>
</tr>
<tr>
<td>Do., below ground</td>
<td>546.31</td>
<td>4,076,004</td>
</tr>
<tr>
<td>Stone miners and quarriers</td>
<td>11.58</td>
<td>8,442</td>
</tr>
<tr>
<td>Do., igneous rock</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Do., limestone</td>
<td>4.67</td>
<td>3,037</td>
</tr>
<tr>
<td>Do., sandstone</td>
<td>37.34</td>
<td>27,791</td>
</tr>
<tr>
<td>Masons</td>
<td>29.77</td>
<td>21,776</td>
</tr>
<tr>
<td>Do., limestone</td>
<td>30.61</td>
<td>22,843</td>
</tr>
<tr>
<td>Do., sandstone</td>
<td>61.28</td>
<td>43,216</td>
</tr>
<tr>
<td>Potters, etc.</td>
<td>17.20</td>
<td>12,836</td>
</tr>
<tr>
<td>Brick, etc., kiln and oven men</td>
<td>15.67</td>
<td>11,004</td>
</tr>
<tr>
<td>Other makers of bricks and pottery</td>
<td>4.33</td>
<td>3,391</td>
</tr>
<tr>
<td>Metal grinders</td>
<td>33.51</td>
<td>25,007</td>
</tr>
<tr>
<td>Cutlery grinders</td>
<td>66.09</td>
<td>40,403</td>
</tr>
<tr>
<td>Artisans</td>
<td>20.13</td>
<td>13,022</td>
</tr>
</tbody>
</table>

After the new laws had been put in force, the percentage fell to 3.28 in 1920-1921, and to 3.22, 3.23 and 3.72 for the following years. It may be added that these statistics include the slight cases, as well as the most advanced, which constituted, in 1916-1917, 0.4 per cent., and, in 1923-1924, 0.02 per cent. (Watkins-Pitchford).

LEGISLATION

Pulmonary affections are compulsorily notifiable in the Netherlands when they affect persons employed in the following industries: glass-making, industries which include work on glass by the rise of the industries: glass-making, industries which are notifiable; in the Netherlands when they notifiable; in the Netherlands when they notifiable; in the Netherlands when they notifiable; in the Netherlands when they notifiable; in the Netherlands when they notifiable. In France, cases of anthracosis from coal dust are notifiable; in Pennsylvania, cases of anthracosis, without any specification; in Poland, silicosis; in France, pulmonary affections from siliceous, calcareous and argillaceous dusts. Among the affections specified in lists for compensation in different countries, those which are concerned with the respiratory passages are:

1. The list of respiratory affections is given according to the terminology used in the different legislative texts.
Asthma from the dust of Acacia melanoxylon ("Blackwood") in Southern Australia. Phthisis in bakers and millers in Queensland; in grinders in Ontario and Germany; in miners in South Africa, Ontario, Alberta, Western Australia, Queensland and New Zealand. Anthracosis or pneumoconiosis in Argentina, Bolivia, Brazil, Chile and New Zealand (for miners with silicosis and tuberculosis); in Germany (for silicosis and pneumoconiosis complicated by tuberculosis); in U.S.S.R. (for miners and polishes; as well as the silicates); in Ontario and Alberta (for siderosis, silicosis and lithosis). Silicosis: Great Britain, Queensland, New Zealand, Ontario (cutting stones and grinding metals); Alberta (for miners, quarriers, cutters and polishers of stone or metals) and Germany. Siderosis: Argentina (steel smelting) and Bolivia. Tobacnosis: Brazil, Argentina, Bolivia. Pulmonary affections from basic slag or standstone: Germany (grinding of metals, the china industry and mines). Cancer of the lung (Schneeberg disease): Germany. Pulmonary sclerosis: Bolivia. Tuberculosis: Argentina and Brazil (see above Anthracosis). Pulmonary tuberculosis: Bolivia, New Zealand (mines).

A New English law of 1930 includes the extension to asbestosis of the compensation laid down for silicosis. See also article "Tuberculosis and Silicosis". As regards the upper respiratory passages, see article "Occupational Diseases: Ear, Throat and Nose".

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Pancoast and Panergrass. "Pneumoconiosis (Silicosis)." New York, 1926.


Prof. M. Sternberg (Vienna).

Digestive System and General Metabolism


Most occupational diseases connected with the digestive organs are brought on through industrial poisons or occupational infections. These etiological factors, as well as the important problem of nutrition, are discussed in the corresponding articles. Other forms of disease relating to the digestive organs do not present any very noticeable variety, but develop according to the usual picture of ordinary illnesses. There is no doubt that here lies the reason they do not receive the attention they deserve, although sometimes they may give rise to very serious trouble. The injury may extend to all parts of the digestive organs, and may cause organic, as well as functional, disorders.

THE OESOPHAGUS

Diseases of the oesophagus are rare, and more searching investigations should be made on this subject. According to American and European statistics, cancer of the oesophagus occurs more often in men than in women (in the proportion 3.5 to 1); the reason for this may perhaps be found in part to be due to occupational risks. In China, the frequency of this disease may be attributed, especially in the case of coolies, to the consumption of hot rice and alcohol; for as is known, these are both chemical and thermic irritants. It is an interesting fact that cancer of the stomach and oesophagus is very common in the Telf district of the Tyrol, where the chief sources of ichthyol are found.

THE STOMACH

The hydrochloric secretion of the stomach is one of the most powerful means of protection, particularly against pathogenic germs which originate in the alimentary infections, but are capable of being killed by hydrochloric acid; per contra arrest of the flow of this secretion favours infectious intestinal diseases. This arrest of hydrochloric secretion may be an occupational lesion, and neither it nor its consequences should be neglected. On the other hand, recent researches have shown that hydrochloric secretion is important from another point
of view, as regards industrial pathology.

Although intellectual work does not increase, to any appreciable degree, the expenditure of energy, it is known that strenuous muscular work, if sufficiently prolonged, lowers the alkalinity of the blood plasma, and increases the acidity of the gastric juice. When the muscular work ceases, the alkalinity of the blood increases, and corresponding diminution takes place in the acidity of the gastric juice.

Thus it is seen that the secretion of gastric juice protects the organism against fatigue; and, consequently, the absorption of food not only supplies the body with the necessary number of calories, but, by increasing the hydrochloric secretion, it readjusts the balance of hydrogen ions in the blood, and thus removes the sensation of fatigue. Food that is rich in albumens is most effectual in increasing the hydrochloric secretion. Here is to be found an explanation of the instinctive desire for such food experienced by men employed on exhausting work who absorb on an average 65 grm. of albumen a day, apart from the fact that lack of albumins quickly induces malnutrition, as has been proved in the case of Zittau weavers.

Occupational diseases of the stomach may be of primary or secondary origin. The latter are chiefly due to the fact that, on account of occupational causes, the teeth are defective, or else they are brought on by one of the numerous forms of stomatitis which involve as sequelae acute and chronic gastritis.

Among primary diseases of the stomach are found nervous complaints, catarrhs, hypochlorhydria, ulcers, carcinoma, and infections.

One of the chief factors in the etiology of diseases of the stomach is irregular feeding, as has been observed in the case of commercial travellers, country doctors and others. Besides this the part played by alcohol must be taken into account in the case of workers connected with inns and hotels, night workers, and especially those whose work is exhausting. For alcohol, while it masks sensations of fatigue,同时也 preserves the premature expenditure of strength. Recent experiments have shown that alcohol prolongs the duration of secretion and increases the acidity — both for hypo- and hyper-hydrochloric stomachs. In this connection mention should be made of those men who drink liquids used for polishing, particularly cabinet makers who suffer from chronic gastritis caused by lacquers.

Gastritis is found in industries in which the workman's stomach is irritated by fresh and highly seasoned meats, especially among men employed in knackers' yards, and often in trades where the workman swallows vapour that contains acids or caustic alkali. This applies particularly to margarine factories, soap refineries and candle factories, where the workmen imbibe, in addition to alkaline vapour, fatty acids, e.g. lactic acid, acetic acid, palmitic acid, stearic and margaric acid (Grun). These substances not only neutralise the gastric acids, but open the way to processes of fermentation and putrefaction, and by destroying the sterilising property of the hydrochloric acid facilitate the development of infectious intestinal diseases, often followed up by intestinal catarrh and catarrhal jaundice. Finally it should be pointed out that men working in high temperatures, e.g. glass blowers and men at gas works, who, on account of the heat, take large quantities of cold drinks, as well as those men whose abdomens are exposed to cold, such as men who work in water, raft drivers, etc., often suffer from gastro-intestinal troubles.

Complaints arising from the gastric secretion, as well as the formation of tumours, may be due to mechanical, chemical or thermic causes. Since it is admitted that ulcer of the stomach, in particular, can develop from gastritis, the aforementioned factors can then be considered as predisposing.

In the case of cooks, ulceration may develop as a result of hyperacidity produced by the constant taking of hot, rich food. This form of ulcer, although its existence has often been denied, is quite possible, though perhaps less common than is generally thought. But it is worthy of note that ulcers of the stomach are found in chlorotic persons and in beginners and apprentices. In reference to this it is important to bear in mind that psychic condition, overstrain and mental excitement may play an important part in the development of this complaint. But the theory, which is accepted at the present time, of the formation of an ulcer on a neurotic basis admits a constitutional foundation and so occupational risks are not so much an etiological factor in this illness as an auxiliary cause; for this reason in cases of haematemesis and in cases of gastric ulcer account must be taken of external and internal injuries.

Dealing with internal injuries there must be placed at the head of the list the swallowing of sharp-edged particles of dust by metal turners, stone cutters, and the like.
As regards external traumatism, unless predisposition plays a part, it must occur daily, or repeatedly, in order to produce ill-effects, e.g. the bent position of the tailor's or shoemaker's body when at work. Some American statistics (Friedenwald and Morrissom) which deal with 200 cases of ulcer of the stomach attribute 2 per cent. to this cause. The development of an ulcer as the result of a single injury, such as carrying heavy loads, or a fall from a height, is a very rare occurrence, and it may be assumed that this is rather a case of making manifest the existence of a latent ulcer. German statistics (Ebstein) show among 157 cases of ulcer of the stomach 6 cases due to injuries (3.8 per cent.). Cases seem more common where confusions of the stomach are concerned.

The question of cancer developing on the foundation of an occupational injury is still less understood than that of ulcers. It is only possible to consider those cancers that are grafted on an ulcer, which, according to Haberfeld's statistics, form 16 per cent., and, according to Orator's statistics for 1925, 10-15 per cent. of all carcinomata. If it be admitted, with Kaufmann, that 3.8 per cent. of ulcers of the stomach are of traumatic origin, and that about 5 per cent. of these will become carcinomatos, it follows that, out of 10,000 cases of ulcer, 380 have a traumatic etiology, and, of these, 19 will eventually develop into carcinoma.

Ochsner's work (The Relation between Filth and Cancer) in which the author asserts that cancers of the skin are commoner among men than among women, and that they are situated on those parts of the body exposed to dirt, such as the face, hands and ears, may be verified. In the same work the author points out that cancer of the stomach is found among Japanese agriculturists, who use excrement as manure, in the proportion of 53.2 cases per 100,000 inhabitants, whereas this disease is unknown among the Eskimos.

As regards the part played by traumatism in the formation of cancer of the stomach, it may be affirmed that a single injury can never start cancer. It is possible, however, that the effect of traumatism on the body is to prepare the way for the development of cancer which has a strong affinity for ulcers and irritated parts. Nevertheless, it is quite probable that a carcinoma of the stomach, which already exists is only aggravated or made apparent as the result of a lowering of resistance, caused either by industrial poisons, by the inhalation of gas, fumes or dust, or else by underfeeding and overwork. The same considerations apply to traumatism which may increase the growth of malignant tumours already existing, whatever be their nature or their localisation.

Neurosis of the stomach plays a still more important part, all the more important because it is partial manifestation of a general neurasthenia. At this point there must be considered the etiological factors due to neurasthenia, the emotion which is aroused by the feeling of responsibility, or by work carried on under the pressure of necessity. Various other factors may of course come into play, e.g. physical and mental overwork, irregular feeding, or excitement day by day; all such things should be taken into consideration — it is very difficult to make a diagnosis — for affections of the stomach are independent of the act of digestion, and of a fixed diet.

In conclusion, it is found that industrial diseases of the stomach, with the exception of forms of neurosis, which are really symptoms and seldom diseases sui generis, are not numerous, and belong partially to the domain of hypotheses which need to be studied more thoroughly.

Intestines

Constipation and its sequelae are the chief occupational diseases of the intestines. As the industrial poisons which affect the intestines will not be considered in this article, the most important point to examine here is atonic constipation. It is not merely the nature of the food (a subject not dealt with in this article), but also the style of life which leads to this form of constipation; for the movements of the body — more than anything else — ensure regularity of the intestinal functions (Strassburger). This form of constipation is found in persons who lead a sedentary life, such as coaches and writers; commercial travellers also suffer from this complaint owing to their long railway journeys.

Another point is that women working in factories are often unduly modest and so bring constipation trouble on themselves. It is important to persuade them not to be so foolish. This complaint is also found in young
In times past, it was accepted as a medical fact — which is somewhat overlooked by modern practitioners — that hernias only formed progressively by the gradual stretching of the fibrous parts, and that intra-abdominal pressure has to be of some years' duration before effecting the stretching of the inguinal orifice which results in a hernia. The sudden development of a hernia is very rare. The prolonged effect of intra-abdominal pressure due to a man's occupation frequently brings on an interstitial inguinal hernia, due to a pre-existing peritoneal pouch, which may become an external hernia. This may also be suddenly brought on by an unusual increase of abdominal pressure. Great physical exertions repeated daily are among the chief causes of hernia.

Kauffmann classifies as follows the traumatisms that are effective at once: first, direct action on the abdomen by blows, shocks or falls; second, slipping or falling when in the act of lifting, carrying or throwing heavy objects or loads; third, efforts made to hoist one-self out of some deep place after falling in, or to raise oneself to a standing position when kneeling or holding some heavy load. These are more or less accidental causes, which bring on a sudden increase of intra-abdominal pressure; they belong to the same group as physical efforts and overstrain, and are conducive to the production of hernia by bringing to light a hernia already existing or by making worse a hernia that is in course of formation.

As well as internal and external inguinal hernia there occurs femoral hernia, often with no symptoms; also umbilical hernia and epigastric hernia, as well as hernias of the lateral walls of the abdomen and in the region of the kidneys, the etiology of which is the same as that of inguinal hernia.

Internal hernias are uncommon and this fact is important for the reason that invagination of these hernias, which develops with symptoms of strangulated intestinal obstruction, is difficult to diagnose.

The most common of these internal hernias is the diaphragmatic, which is produced through a diaphragmatic hernial sac formed by the peritoneum or pleura, in contrast to false hernias, the most common of which occur by the passage of an intra-abdominal organ into openings between the abdominal and thoracic cavities; both forms occur chiefly on the left side of the diaphragm (Strassburger).

In addition there should be mentioned duodenal-jejunal hernia (penetration
of the intestine into the duodenal sac), hernia into the omental cavity (by the opening of Winslow), hernia of the intersigmoid sac, hernias of peritoneal pouches and hernias of the parajejun al sac. These hernias, although difficult to diagnose, should be mentioned here.

**Vascular System**

Another occupational disease brought on, or at least influenced, by the occupation is dropsy. This condition was recognised in medicine in ancient times, but its importance has been specially emphasised in modern times, particularly by Walko, and it should be mentioned here on account of its intestinal symptoms. This disease occurs more commonly in men than in women, in the proportion of 3 to 1. Its development depends chiefly on hereditary and constitutional factors, but also on an unhealthy kind of life, which is for the most part sedentary.

This disease is chiefly found among clerks, among people who work in offices, and among those whose work is of a sedentary nature. Up to the present time, very little attention has been paid to these conditions of work, and it would be a good thing if precautions against this disease could be taken in the case of tailors, shoemakers and office clerks. It often shows itself by serious digestive troubles of every kind, and by anaemia; it develops in people who lead sedentary lives. In these cases there is congestion of blood in the abdomen and interference with the flow of venous blood, as a result of the kind of life, or of some constitutional weakness of the vascular system. The next thing one observes is a condition resembling collapse and an increase of arterial pressure. But these cases may also indicate dyspeptic complaints which cause loss of flesh. Gymnastic exercises and hydropathic treatment are useful for preventing this occupational condition.

Arteriosclerosis of the intestinal vessels resembles general arteriosclerosis in its etiology, and so may be passed over in silence in this article. In the same way that the circulatory system may be affected by the abdominal cavity, so the heart may cause most serious intestinal disorders. This explains how, after a great physical effort, a failure of the valves of the heart to act may bring on embolism of the mesenteric artery, with intestinal gangrene, and a fatal issue from peritonitis — though this is rare.

**Abdominal Musculature**

Flabby muscles, which are commonest among women who have had a good many children, display, especially when the abdominal pressure is increased by work, a tendency to enteroptosis with displacement of organs, and also to plethora and its consequences. Massage of the abdominal muscles and eventually the use of the Bergonie apparatus are recommended as preventive measures. At all events, working women who suffer from flabby muscles should avoid heavy work, and the same advice holds good for any one who suffers from constitutional weakness of the abdominal wall, from ruptures, fistulas or scars which are imperfectly healed.

**Liver**

Except in cases of poisoning, occupational diseases of the liver are not, as a rule, primary affections. There should first be mentioned cirrhosis of the liver which is found very commonly not only in what are called the alcoholic trades, but also amongst other categories of working men who consume large quantities of alcohol; men who work either at very high temperatures or at very low ones, or in a dusty atmosphere, or who handle poisons. But chiefly to be considered are men who do very heavy work, and take alcohol to dull their sensation of fatigue. Various opinions concur in holding that cirrhosis of the liver may have a traumatic etiology, in the same way that aggravation or rupture of varicose veins in the oesophagus may be the result of accident or of a physical strain.

Passive congestion of the liver may also be looked upon in a certain sense as an occupational disease: first, because the circulatory system is often out of order, especially in the case of men doing heavy work, with congestion of the liver as a result; secondly, because sedentary work, especially in the case of women workers, often brings on passive congestion of the liver with the formation of biliary calculi, besides plethora and stomach troubles.

**Pancreas**

Injury to the parenchyma of the pancreas is produced in the same way as injuries to the liver; traumatisms may cause necrosis, and, according to Von Noorden, eventually diabetes. As regards this latter disease it is pretty certain that predisposition is its essen-
tial starting point, and that certain occupational factors, e.g., emotions or intellectual overstrain, are only intensifying or determining causes.

Fortunately in these days a young man suffering from diabetes need no longer be a burden to the community. For, as has been learnt, chiefly from Jaksch’s experiments, based on the discoveries of Banting and Best of Toronto, it is quite possible to restore to a young man suffering from diabetes his capacity for work, by teaching him how to regulate his diet and how to make use of insulin. Jaksch’s clinic is almost entirely filled with ordinary workmen, who, with the help of Trommer’s test, have been giving themselves insulin injections for years and, thanks to a suitable diet, keep up their capacity for work. The social problem of restoring certain diabetic patients to become active members of the community is no longer an impossible one; it is only a question of distributing insulin free, or at a greatly reduced price.

DISEASES CAUSED BY LACK OF VITAMINS (DEFICIENCY DISEASES)

Under this heading, for simplicity of classification, are grouped diseases due to nutritional changes, which are caused by the lack or deficiency of a substance, or of a group of substances, or, perhaps, simply of a physico-chemical condition of the food, necessary in minimum doses to nutrition (Weill and Mouriquand).

These diseases, due to lack of vitamins which English and American bio-chemists call “food accessory factors”, are chiefly beri-beri, scurvy and pellagra.

Beri-beri, characterised by a poly-neuritic syndrome, or by an oedematous syndrome generally associated with cardio-vascular complaints, is a disease associated with the lowest classes of society, and is found chiefly among the Chinese coolies. It is also observed among certain classes of Japanese workmen, among the poorest classes of the Malay Archipelago, in South America and South Africa. The consumption of decorticated or polished rice is the chief cause of this disease.

Nocht has described a form of beri-beri observed among German and Norwegian sailors, who live on sailing ships for months at a time. This form is characterised by oedema of the lower limbs, with paresthesia, cardiac enlargement and weakness, and digestive troubles. It often ends fatally.

The disease is due to the consumption, almost exclusively, of preserved viands, and is often associated with scurvy.

Bad hygienic conditions are also considered by some authorities to be important factors in the disease.

Scurvy, which in peace time is in these days an unusual disease, appeared in the form of serious epidemics during the war, when populations and armies suffered from general dietetic restrictions, or from privation of fresh foods. In days gone by, the by-product was the appanage of long sea voyages, besieged populations, armies on the march, and Polar explorers. The same may be said of ergotism, which of yore was so common among rural populations that it was given the name “Morbis ruralis”. The progress attained by the modern flour-mill industry has made this illness rare.

Among disorders of nutrition connected with a man’s occupation pellagra should be placed first. It is considered in these days to be due to a lack of vitamins, and is attributed to the consumption of deteriorated maize. It is a very common complaint among the rural populations of Southern Europe, Asia Minor, Lower Egypt, Algeria, Tunis, and also of the Southern States of North America. The endemic foci have remained unaltered for more than a century, and the disease affects agricultural labourers almost exclusively. In Rumania the ratio between the pellagrous peasants and town-dwellers is as 50 to 1. The disease, which has been thoroughly studied by Italian experts, is characterised by the following three symptoms: (1) erythema; (2) digestive troubles; and (3) nervous troubles. The erythema appears on those parts of the skin exposed to the sun, as pellagra makes the skin very sensitive to the action of the sun’s rays (“mat del sol”); the skin peels, goes a dark colour, and the surface becomes rough and parchment like—hence the name pelle agra or rough skin. The erythema is accompanied by giddiness, depression, dyspepsia, diarrhoea, and, especially, by pain in the hands and feet, and a reeling gait. The digestive troubles show themselves by salivation and dyspepsia, and by a condition similar to that of dysentery, which may lead on to loss of flesh and finally death. Nervous troubles are both motor and psychical; they are manifested as quick reflex movements, by muscular fibrillary tremor, by parasthesias, pruritus, paresis, paralyses, muscular atrophy, ataxy, conditions resembling tetanus and meningitis, by nocturnal blindness, psychoses, and mental disturbances.
These diseases can best be combated by improving the food of the poorest working classes. Pellagra undoubtedly exerts a harmful influence on the germ plasm.

**Prophylaxis**

The principle of prevention being better than cure is above all true when dealing with industrial diseases of the stomach and intestines. It is for instance so easy to prevent chronic constipation and all its accompanying troubles, the least serious of which is disinclination for work. This complaint is chiefly connected with the sedentary occupations, and the following principles should be instilled into the classes of workers involved. First, the foundation of their diet must be made up of vegetable food, rich in cellulose, for instance black bread, soldiers’ bread, Pumpernickel (Westphalian bread); secondly, some leisure time must be devoted to physical exercise in the fresh air, and some mild sports must be taken up, e.g. gymnastics, riding, cycling, swimming or boating. It must, however, be borne in mind that constipation is equally common in the occupations calling for a lot of exercise, such as among agriculturists, officers and postmen, but in this case the constipation is caused by a spasm of the intestines and the treatment for this is rest, antispasmodics and a soothing diet. The prevention of chronic constipation is possible and necessary, not only with a view to the elimination of such toxins as indican, which diminish the capacity for work, but because in this way serious illness may be avoided, illness which may affect other parts than the intestines (according to Eichhög; iridocyclitis, for example). In preventing constipation the risks of cancer of the rectum, which may be provoked by hemorrhoids or constipation, are also being reduced.

There will not be described in this article the therapeutics of chronic constipation, which in some respects resemble the prophylaxis. But it may be said in passing that the same measures of prevention must be taken for abdominal plethora, and that particular care must be taken when there is hereditary predisposition. Sedentary occupations need to be balanced by physical exercise and stimulation of peristalsis.

As regards pellagra it is unnecessary to enumerate here the regulations made by various countries (Italy, Austria, Hungary, etc.) for combating this disease. Suffice to say that, as regards avitaminoses, beri-beri appears on the list of occupational diseases which are granted compensation in Yugoslavia (only for sailors), and scurvy amongst sailors is compensated in Germany.

It is unnecessary to discuss here the therapeutics of industrial gastro-intestinal diseases, for they are exactly the same as for other internal disturbances. But a few words may be said as to their industrial orientation.

First and foremost hernia must be avoided. It is obvious that this form of lesion forbids the lifting and carrying of heavy objects, standing for any length of time, work at sewing machines, blow-pipe work and using wind instruments. People suffering from hernia are often hampered in their movements; in this case operation is advisable, especially as it is a simple and safe procedure which has, as a rule, satisfactory results. Whilst there is no risk in advising an operation in a case of hernia, especially as the best truss obtainable is inadequate if the man is to do heavy work, an operation in the case of other diseases of the abdominal organs must not be undertaken lightly.

In cases of repeated attacks of appendicitis there should be no hesitation in recommending an operation in the interest of capacity for work; for in these cases the purely medical indications are identical. The doctor's responsibility is far heavier when he recommends an operation chiefly on economic grounds with a view to maintaining the capacity for work. This, for instance, applies to a case of ulcer of the pylorus or duodenum, or to a case of biliary or renal calculus. Here has to be faced the question of an unhealthy constitutional condition which cannot be avoided. But even in these conditions an operation should be decided on if repeated attacks keep on impairing to a noticeable extent the capacity for work. By means of the operation the patient recovers for a time at least, and sometimes for quite a long period, his full capacity for work.

These problems are not firmly enough fixed in the medical mind as yet, and their solution involves not only extensive medical knowledge, but also a very complete acquaintance with the individual's economic conditions, and of his means of holding his own in the labour market.

Yet another point arises with regard to diseases of the abdominal organs; that of deciding how long sick men can remain capable of work. Perhaps prognosis may be fairly easy to make
in a case of carcinoma; but it is far more difficult when it is concerned, for instance, with a question of organic disease of the pylorus, with resulting dilatation of the stomach; and it is still more complicated when one is face to face with the onset of cirrhosis of the liver. The doctor, in this case, has to weigh up accurately the relation between the capacity of reserve energy and the possible industrial injury. He must have a high standard of medical knowledge; he must be able to consider each case from a strictly individual point of view, and also be able to draw upon his own knowledge and experience; for at the present time there is no fixed rule of action in this field of medical work.

The scientific development of industrial medicine in this direction should, in the interest of the workers, be hastened as much as possible, for with it is connected the solution of other difficult problems, such, for instance, as those of nervous diseases.

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**Nervous System**


The incessant progress of industrialisation in civilised countries, which has even extended since the war to countries up till then relatively uncivilised, has necessarily increased the demand made on the nervous system. Under the conditions created by the war and during the first phase of industrialisation, unemployment, worry, scanty nourishment — in brief, all the forms of social wretchedness — have made their pernicious action felt on the sanitary condition of the population. It was, however, possible to determine the causes of this damage and to minimise them to some extent.

A review of industrial diseases as surgery as this must be does not allow of a complete account of all the harm that industrialism may exert on the health of the workpeople, such as the development of fatigue, the increase in the spread of venereal disease, especially of syphilis, alcoholism, etc., which have been found among the workers of all industrial communities, with the exception perhaps of very few countries. As a consequence, there has been a parallel increase in nervous and mental diseases.

A brief description only will have to be given of the nervous and psychic diseases which may be regarded as an immediate effect of the occupation, as such meriting the appropriate title of occupational diseases.

Mention only is made of such maladies as are outside the central nervous lesions due to toxic agents or infections as, for example, those due to the growth of parasites (cysticer cus, echinococcus, distoma, actinomycosis).

1. **Spinal Cord**

Occupational diseases of the spinal cord may be due to poisons: these cause especially myelitis and are mainly due, apart from alcohol, to lead, arsenic, carbon disulphide, chloroform and carbon monoxide; the last-named poison can even, as the result of multiple haemorrhages, bring about the signs of sclerosis. Lesions due to temperature (rheumatism and rheumatoid myelitis, sclerosis following chill) are met with among persons exposed to bad weather conditions (peasants, foresters, farm labourers, workpeople, soldiers, etc.).

Traumatism, severe effort and fatigue result similarly in myelitis, haemorrhage into the cord (especially as the result of carrying heavy loads), sometimes sclerotic patches, myelomalacia (among workmen employed in caissons, and divers), syringomyelia (the temperature anaesthesia of chauffeurs, erectors, blacksmiths, etc.).

Locomotor ataxy (tabes dorsalis) is a post-syphilitic disease and cannot be classed as of industrial origin except in so far as the circumstances of the employment may hasten its evolution.

In studying the outside factors influencing tabes, L. Rosanes has tried to fix what is the part they play in determining or aggravating it. Alcoholism with its tendency to provoke nervous troubles clinically close to those of tabes, perhaps plays an important role in para-syphilis by impeding the power of regeneration of the nerve cell.

In the case of saturnism sometimes met with, it is difficult to rely on a like explanation, the clinical picture differing so much from that of tabes.

Sudden chill may assist in the development of tabes. Physical fatigue, the result of the war, has provoked a very clear recrudescence of tabes in women.

Injury has in many cases exercised a very definite part, but the part which coincidence may play ought not to be forgotten. Industrial fatigue may play a part in the localisation of tabes: amaurosis has shown itself especially in subjects whose life work is exacting and close (mechanics, seamstresses, shoemakers); the symptom known as perforating ulcer affecting subjects who are subjected to constant standing.
2. NEUROSES

It is not the intention here to study how far industrial neuroses constitute especially a symptom of general nervous exhaustion, and to review the consequences of chronic fatigue or a manifestation allied to general neurasthenia; or again to go into questions belonging to the vast field of injuries or fatigue.

With the progress of knowledge of general nervous maladies it is now possible, thanks to the researches on fatigue, to make distinction in different cases as to whether the cause is industrial or not. Whatever be the truth at the present time, it is desirable to review the field of occupations which bring about occupational neuroses.

Industrial work, the utilisation as readily as possible of the forces of labour, the mechanisation of numerous industrial jobs, the monotony of the operations which convert the workman more and more into a machine, all have a decidedly injurious psychical effect. In spite of the different efforts made to interest the workman in his task (sharing in benefits, social work of all kinds), the fact remains that the majority of industrial workers have lost joy in their work. The wage question is the one and only interest and the principal object; the fear of unemployment, of inability to work, increases the nervous condition and adds naturally to discontentment, to strikes and measures of reprisal on the part of the employers.

All these matters affect even more intellectual workers. In many countries the war has destroyed many values, thousands of men wounded; during its course are more or less affected in their capacity to work or have become incapable of work. Effort has been made to parry these injurious consequences, but it has even led to an increase in the unemployment of the intellectual workers, technical experts, chemists, medical men, lawyers, etc.

These circumstances, together with the political instability which still prevails in the world in spite of all the efforts of peace organisations, render the struggle for existence still harder. Functional neuroses are sufficiently frequent; it will suffice to mention their many causes: infections, intoxication, over-pressure, injuries; and outside the factory the role played by food, housing, etc.

Workpeople are also to-day a prey to neurasthenia, a functional neurosis implanting itself on a pre-existing state of loss of nervous energy, and due principally to anxiety arising from the feeling of instability and insecurity. It is found among all classes of society.

The feeling of responsibility is another cause of neurasthenia and explains what is met with among medical men, locomotive-drivers, chauffeurs, railway workers, telegraph and telephone operators, managers, police agents, transport workers in large cities, etc.

Very often injuries set up a hyster neurasthenia which shows itself in symptoms such as those commonly met with: cerebral, spinal and visceral affections.

Hysteria is not a malady peculiar to women; it attacks men also. The emotions, injuries, intoxication and nervous contagion facilitate its appearance. Traumatic hysteria bears a close resemblance to common hysteria.

The anxious state of mind of a person who has met with an accident and is expecting to receive compensation is also a very important etiological factor.

Forms of neuroses were studied among the victims of the first railway accidents. This morbid condition was described by English surgeons under the name of "railway brain" and "railway spine" because cerebral and spinal symptoms dominated the clinical picture.

While traumatic neurosis was denied at first it is now fully accepted following on the numerous observations made.

Certainly traumatic neurosis among healthy people is rarer than was believed because generally it only affects individuals with a personal or family neurotic susceptibility. For a long time much was talked of "malingering" in these forms. Charcot said that the idea of malingering was very often based on the ignorance of the physician. And as a matter of fact these cases only vary within the very wide limits of 1.5 to 36 per cent.

Social legislation, especially compensation for accidents, has caused an increase in these cases of so-called malingering; but they should not be exaggerated because authorities believe that they are not the principal nor the most important cause of this increase.

Certain instantaneous cures after payment of compensation have been looked on as proof of malingering whereas, on the contrary, they are due to auto-suggestion which is as real as a complaint although of purely psychological origin (Cevidalli).

These cases, which are classed under the name of malingering, are really very rare. One in 5,000 cases of accidents in Austria; 12 in 24,000 accidents on the Italian railways; 3 observed by
Bernacchi during twelve years among 23,000 accidents (Allevi).

Traumatic neuroses are then generally the expression of the predominance of a lack of will power in face of certain circumstances as the result of an emotional state bound up with some economical interest or other. According to this view aided by analysis of phenomena, in accordance with present knowledge of neuroses generally, the picture of a traumatic neurosis has the character of an anxiety neurosis or "sinistrosis". Hence the diminished importance, as a predisposing factor, to be attached to it in poisoning.

Injuries of the head or other parts of the body are often the cause of a psychosis which may occur suddenly (rare), but more frequently does so after the lapse of some time. The psychical effects are rarely immediate; they come on as a secondary phenomenon and may be accompanied by malaise, headache, paralysis, etc. Sand is of opinion that psychosis appearing five years after an injury can have no relation to it.

Individual or family predisposition is not absolutely necessary nor has the seriousness of the accident an absolute value. The injury sets up all the clinical symptoms of mental disease: psychosis, hysteria, epilepsy, etc. The victims of accidents who have difficulty in obtaining compensation when affected by traumatic neurosis show the symptoms of paranoia, agitation or persecution mania. Further, as a result of trauma cases of mania, melancholia, mental confusion, progressive paralysis and delirium tremens are described.

Lastly, the neurosis of telephonists (see that article) and tetany which can, although rarely, be set up by lead, phosphorus, chloroform and atropine should be cited. Frankl-Hochwart found among 399 cases of tetany, 174 shoemakers, 95 tailors, 26 cabinet makers, 20 locksmiths and 19 lathe workers. This malady has also been described as shoemakers' cramp.

3. CRAMPS

The neuroses of most importance from a practical point of view are those affecting co-ordination of movement, such as occupational or professional cramps, which are characterised by tonic and clonic spasms, by tremors or paralytic affections. They occur only in connection with a functional or customary professional act and are localised in certain muscles habitually accustomed to perform harmoniously this regular act (Macé de Lépinay). These affections are incorrectly described as cramps, spasms, and loss of power. They would be better described by the term "dyskinesias" (Jaccoud) or "professional neuroses of the co-ordinating centres" (Benedict). They ought not, according to these authorities, to be described under the name of neuralgias or occupational palsies.

These accidents with their selective qualities only occur under two conditions: hereditary predisposition of the subject and frequent repetition of the same functional act. These conditions are necessary, but one of them alone is not sufficient.

In some they originate peripherally, in others centrally, but whatever be the origin, it is necessary for the condition to take on its peculiar features — that the mental factor should always enter. In not a few of the cases some definite anatomical lesion is present in the affected member — arteritis, myositis, synovitis, neuritis, but in the majority of cases no local lesion can be found.

The prognosis in every professional form of cramp should be given with reserve and should be based on the cause which has given rise to the affection; on the existence or pre-existence of other neuroses; on the mental state of the patient; on the length of time the malady has been present.

The professions concerned are very various. Without giving a complete list, it may be recalled that Oppenheim has described in his book a cramp occurring among pianists, violinists, flautists, violoncelliists, harpists, organ players, drummers and orchestra conductors. A professional cramp has been described as affecting seamstresses, telegraphists, shoemakers, cigar makers, watchmakers, hairdressers, folders of newspapers, locksmiths, tinsmiths, nailmakers, workers in wool, silk ironers, florists (making bouquets), fencers, motorists, milkers, etc. Oppenheim considers that the cramp observed in sawyers and similar manifestations in quite a number of other trades such as turners, saddlers, cabinet makers,Waiters, ought all to be classed among professional palsies of neurotic origin.

The typical neurosis of this kind is the well-known writers' cramp (graphospasm, metathorgraphia) which is distinguished according to its main symptoms as a form of contraction either paralytic, or a tremor or a neuralgia. Writers' cramp may occur as an occupational malady in all the professions where it is necessary to write much and rapidly, that is, among
those employed in commerce, in offices, among shorthand writers, officials, etc.

As a result of the introduction of typewriting machines this neurosis has become rare; but it is still met with sufficiently frequently among typists, who are often badly paid and obliged to work overtime. Long continued shorthand-writing fatigues the hands, and the nervous system is injured by a state of general fatigue, especially when work is done at night.

Oppenheim has himself observed a form of cramp in a hairdresser in the act of shaving (cheirosparasm or xyrosparasm which he distinguishes from cheirophobia). Professional neuroses have been described among diamond cutters and money changers. Here it is a combination of neuroses and difficulty in co-ordinating movements of the upper limbs.

This lesion similarly although more rarely affects the lower limbs in dancers, soldiers, tradesmen's tri-cyclists, seamstresses, sewing machine workers, knife and scissor sharpeners, harp players (muscles of the calf), etc.

Identical cramps of the muscles of the head are still rarer. Cramp of the tongue in clarionette players and of the lips in trumpet players have been described by Oppenheim, who cites also certain cases of neuroses due to continued microscopical work (spasm of the muscle of accommodation), in watchmakers (spasm of the orbiculoris), and nystagmus analogous to that of miners in a cathedra. Statements as to traumatic lesions of the peripheral nerves as a consequence of injuries which can, under certain conditions, be regarded as industrial accidents, it will suffice to bear in mind that they also involve medical considerations in the domain of industrial medicine, especially when these lesions arise from small repeated multiple injuries in the course of work (pricks, bruises, wrenches, cuts and, more particularly, pulling strain and pressure) which are important in that they may give rise to paralysis.

Under the name of professional neurites, Oppenheim includes injury caused by continuous pressure of a tool on certain nerves bringing on inflammation.

In the upper limbs neuritis of the ulnar has been described, with paralysis and paraesthesia, among other symptoms in bicyclists, metal turners, watchmakers, hat finishers, glasscutters, tanners, bilhors, cabinet makers, shoemakers, glassblowers, typists, engravers, telephone and telegraph workers, diamond and crystal cutters, violincellists, ice-sawyers, waiters, poker workers, bakers, healers, workers in incandescent lamp factories, etc.

Neuritis of the median nerve has been observed in finishers, cabinet makers, locksmiths, carpet beaters, dentists, blacksmiths, etc., and in a cutter in consequence of continuous use of a pair of scissors.

Neuritis of the brachial plexus has been found in watchmakers, cabinet makers, gymnasts, boiler makers, soldiers, shoemakers, carriers of heavy loads (Oppenheim and Salomonson), etc.

Professional neuritis of the muscles of the hands has also been described in sedentary professions (professors occupied at their desk, office workers, book-keepers, seamstresses, shoemakers, etc.).

The distinction between neuroses and professional neuritis may sometimes be very difficult — especially when the two are combined — and may even be impossible if the classical symptoms of neuritis (muscular atrophy, reaction of degeneration) are not present. On the other hand, the signs of muscular atrophy may be the prodromal indication of a progressive muscular dystrophy, disease of the spinal cord, so much so that every care must be taken as to prognosis in each case.

Even when the diagnosis of neuritis is certain, it is not always easy to say, in every case, whether it is a neuritis due to the occupation or not (infection, alcoholism).

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among coachmen (Raynaud, Constelmont), as well as an occupational palsy among lithographers (Vogt). Under the name of occupational paralyses, Oppenheim has described in accordance with observations of Bergen, Remak, Leudel, Bernhardt, Baraks-Dvidlicky, Hunt, and of his own, an atrophy of the first interosseous muscle and of the opponem pollicis in a file cutter, muscular atrophy in file cutters, paper folders. Some of these are workers indeed in whom the possibility of lead poisoning is not excluded.

Neuritis of the lower limbs is less frequent: it affects the cranial, nerves of the leg, especially of the fibula in the case of turners, sewing machine workers, workpeople in a bent position, employed in weeding or digging potatoes or peat, asphalters or street pavers, or persons employed in laying drains. Neuritis of the tibial has also been observed.

Fatigue is further often the cause of neuritis which complicates the occupational neuritis among cigar rollers (Coester), among sandworkers and letter sorters (Steiner).

5. CRANIAL NERVES

Lesions of the cranial nerves are rarer and due to poisons, particularly to lead (loss of the sense of smell, paralysis of the recurrent nerve, of the hypoglossal and eye muscles). Lesions of the auditory nerve are due especially to explosions; lesions of the optic nerve to the injurious action of luminous rays, toxic substances (methyl alcohol: polishing furniture), or are met with in processes involving fatigue of the eyes (engravers).

Mention ought to be made of the fact that toxic and infectious paralyses may be associated with occupational neurites (toxico-professional palsies of Oppenheim), as, for example, atrophy of the small muscles of the hand such as occurred to a woman during her convalescence from influenza, after working at sewing.

Poisons of the Nervous System

Cases under this heading constitute forms merging into real toxæmias of the nervous system, which may be produced in the course of general occupational intoxications, but sometimes (polysymptomatic saturnine neuritis) in the arms and legs often constituting a syndrome of arsenical pseudo-taebes, because involved in it are difficulty of speech, optic neuritis, and epileptiform seizures. Diagnosis per se can be established when the case history brings out the possibility of arsenical poisoning, but
especially from the examination for arsenic (in the urine, hair, etc.).

Diagnosis of manganese poisoning is more difficult, involving as it does psychical changes (laughing, crying), loss of sensation of paralyses, and notably difficulty in walking and speech, which sometimes lead to mistaking this form of poisoning for a disease of the spinal cord. If the mangano-phobia among workers in manganese described by Jaksch is borne in mind, special care is necessary before making the diagnosis of true manganese poisoning.

Industrial maladies from phosphorus, chrome, antimony, zinc and silver do not lead to special nervous changes—at least not when uncomplicated by lead as is the case with certain chromé colours.

On the other hand hydrogen sulphide, carbon disulphide and chronic poisoning through carbon compounds do bring about nervous changes. Those due to hydrogen sulphide include headache, vertigo, delirium, somnolence, and sometimes attacks of fury or a condition of stupor. In those with chronic poisoning have been described of inco-ordination of movement, paralyses, mental affections amounting even to dementia—symptoms well known in chronic poisoning from sewer gas or emanations from cesspools.

In poisoning from carbon disulphide the nervous symptoms are still more prominent. Following prodromal symptoms of headache, paralyses of the extremities, then a condition of maniacal excitement, which may last for weeks or months, followed lastly by psychical depression and sometimes by psychoses and forms of neuritis. The diagnosis is at times difficult, especially if knowledge of the exposure to carbon disulphide is missing. Erben recommends the following reaction: pass expired air into a colourless alcoholic or ethereal solution of triethylphosphine. The red colour produced by the carbon disulphide is very useful in deciding the diagnosis.

Non-fatal poisoning by cyamogen compounds produces paralyses of the extremities, hallucinations and, in chronic cases, insomnia, delirium, and paralysis of the pupil have been described.

Chronic poisoning from carbon monoxide is the most important from a practical point of view because it occurs far oftener than all the forms of poisoning previously mentioned. The nervous manifestations consist principally in paralysis, cramps, affections of sight, and psychical disturbance varying from simple amnesia (loss of memory) to states of the most violent excitement psychosis analogous to the psychosis of Korsakow, pseudo paralyses, and multiple scleroses. Diagnosis may be difficult in certain circumstances when the action of carbon monoxide is not borne in mind. On the other hand, other forms of intoxication may be mistaken for that of carbon monoxide. Moreover, it is the chronic poisoning which presents the greatest difficulty in diagnosis.

Functional affections of the nerves have been described: pseudo-tabes, pseudo-paralyses, multiple scleroses.

Neither phosgene nor nickel carbonyl, substances very similar to carbon monoxide, appear to cause nervous symptoms as there is no reference to this in medical literature.

Poisoning by carbon dioxide produces symptoms of asphyxia, but not any special nervous affections.

Organic toxic substances give rise to a host of nervous affections, as the result of the industrial poisoning they set up. Their number is very great and mention only of the most important will have to suffice here.

Petroleum benzine induces relatively often industrial poisoning by inhalation. In the chronic form it causes sensations of tension in the head, loss of the power of thought, nystagmus, fibrillary tremor of the tongue and hands, and loss of sensation to pressure in the nerves.

Crude petrol containing lower hydrocarbons brings about symptoms analogous to those of the pure substance.

Ethyl alcohol, which may be considered the most widely spread of all nerve poisons, causes in drunkards very well known lesions: alcoholic psychoses, poly-neurites, affections of sight. Little known are the professional lesions of brewers, hotel keepers, waiters, barmen, commercial travellers in wine, draymen—in short, all professions having to do with the manufacture or sale of wine or spirits. Among the higher alcohols amyl alcohol alone need be mentioned, inhalation of the vapour of which causes agrypina and chromatopsy.

Professional ether intoxication is rarely met with, and with the exception of occurrence of the Korsakow syndrome no mention of lesions of the nervous system is to be found in literature.

It is not possible to say whether persons who have indulged in ether (medical men, chemists, and their assistants, nurses), suffer ill-effects from it. In the cachexia due to ether, psychical disturbance may occupy a prominent place, as in all toxic manias as is well known; but what is least known is that children may derive the habit of ether drinking when, for example, their bread when taking their petits déjeuners is dipped in this substance (Erben).

A pernicious effect from the use of chloroform, as in the case of ether, has been observed in invalids when chloroform has been administered in the form of frictions, but also among chemists, druggists, medical men, and their wives, nurses, etc. Professional poisoning from chloroform has been observed in rare instances among surgeons and their assistants after its long use for operative purposes. One case has been reported in a chemist from pouring it from one vessel to another.

Ethyl chloroform which is used as a local anaesthetic and also for inducing narcosis
of short duration rarely induces poisoning and nervous affections.

On the contrary, hypnotics, like chloral hydrate, veronal, trional and other similar substances, in consequence of dosing in persons having the care of the sick, may cause serious nervous lesions.

Benzene, in consequence of its extremely wide technical use, causes acute and chronic poisoning. Inhalation of benzene vapour sets up headache and vertigo, buzzing in the ears, intoxication, and if inhaled for long convulsions and finally narcosis. In chronic poisoning delirium, apoplexy, hemiplegia and cramps are described.

Similar manifestations can be produced by toluene (Koelsch) and xyylene (Erben). According to Lehmann this latter substance is one-fifth more and toluene two-fifths more poisonous than benzene; they induce a more rapid narcosis and require a longer convalescence.

Among the poisons of the aromatic series, particular mention should be made of the nitro derivatives, of which nitrobenzene, in addition to blood changes, causes paraesthesia, troubles of co-ordination, convulsions, anaesthesia, and trinitrobenzene, trinitro-naphthaline and trinitrotoluene cause very serious nervous lesions. That, at any rate, is the view of Koelsch when dealing with the cases of poisoning from these substances which occurred in Great Britain and Germany. He describes the manifestations produced as follows: loss of consciousness, vertigo, numbness, insomnims, depression, mental weakness, affections of the sight, delirium, cramps.

Industrial poisoning from picric acid, as observed in one case, gave rise to pains in the legs, drunken gait, paraesthesia, loss of reflexes, pains in the nerves of the thigh, and neuritis (Koelsch).

Antimony, which is a special blood poison, causes sometimes symptoms of excitement and paralysis of the central nervous system. In serious cases generally delirium of the pupil, somnolence, coma, convulsions and occasionally difficulty of walking simulating drunkenness, or maniacal excitement are observed. In chronic poisoning, besides the tumours of the bladder, there are nervous symptoms: unsteady gait, vertigo, inco-ordination of movement and loss of sensation.

Among the toxic effects of aniline colours, not infrequently arising from impurities in them, mention should be made of paralyses caused by certain nitro and amido compounds.

Among the vegetable poisons rich in effects on the nervous system (such as curare, strychnine, physostigmine, pilocarpine, nicotine, caffeine, emetine, atropine, cocaine, opium, with its innumerable alkaloids especially morphine, and strychnine, many 'opium, morphine, nicotine, and, in later times, cocaine) have assumed great importance from the point of view of toxicology, but in regard to these it is not possible to speak of professional poisoning except in the rare event of their affecting workmen in chemical and pharmaceutical factories, or persons who handle them (doctors, chemists, druggists and nurses). The serious psychical and nervous effects of morphine and cocaine in drug addicts are so well known as to make it necessary to describe them here.

Nervous effects from tobacco which are met with usually in those who chew or cut off the ends of the rolls of tobacco with their teeth (Tabakwitzel) are shown in ambylopia, neuritis, even of the auditory nerve, and sometimes, psychoses. The effects of tobacco on the workmen in tobacco factories have been much discussed (see that article).

Poisoning among those who gather mushrooms is recognised (poisoning by the false amanita for example), as well as among persons who have charge of poisonous animals (snakes charmers, custodians of zoological gardens, laboratory research students and their assistants).

All these poisons may affect the nervous system and especially the upper limbs. Where there is a question of compensation these cases may cause symptoms suggesting malingering.

There has thus been rapidly passed in review those lesions of the nervous system which have their more or less evident cause, and even at times their material causes easily distinguishable as such in work; lesions of the nervous system produced by alcohol, syphilis, excessive use of certain muscles and nerves, and toxic substances, causing nervous lesions.

All these facts are closely connected with the pernicious effects of alcoholism, syphilis, influenza and other infectious diseases favouring or causing nervous and psychical maladies. At the present time, however, signs of a better understanding of these conditions are visible. For some time past, especially in America, great attention has been bestowed on mental hygiene. National committees have been founded in several Continental countries. This movement is in its earliest days; unfortunately it is too little known to the majority of medical men, and to the mass of workers and their trade unions.

LEGISLATION

Legislation in the Netherlands requires the notification of optic neuritis affecting coke furnace workers, gas workers, photo-engravers, autogenous cutters and welders; reporting of peripheral paralyses among asphalt workers, dock labourers, milkmen, washerwomen, labourers, pavers, those employed as chemists, ironers, potato-diggers, weavers; reporting of occupational cramps in cigar workers, seamstresses, dancers, those engaged in writing, metallurgists, musicians, pianists, knitting machinists, and watchmakers.

Compulsory notification is required in France of lead encephalopathy (Decree of 4 May 1921) and in Poland of optic neuritis.

The list of scheduled diseases under the Workmen's Compensation Acts include occupational diseases of the nervous sys-
Locomotor System


What is known as the "locomotor apparatus" will be dealt with in the first place on account of its accepted pre-eminent importance. By this apparatus is meant the combination of parts represented by the muscles, bones, cartilages, articular capsules and ligaments which constitute the lower limbs, with their three principal segments, the thigh, the leg and the foot, which are joined together and on to the trunk by three large articulations: the hip joint, the knee and the tibio-tarsal joint. The muscles are active force-exerting organs; they act through the bones, which are passive structures into which they are inserted. The bones are mobile levers moving on fulcrum points or joints. The movements originate from the central nervous system, sometimes by voluntary action, sometimes by reflex action, with a diphasic rhythm of contraction and relaxation. The mobility of the human body during locomotion depends upon this balanced rhythm, and upon the mobility of different segments of the body, kept in check by partial movements.

Locomotion is almost exclusively a function of the lower limbs, for it is only under special circumstances that the upper limbs are called upon to assist, as, for example, in swimming, crawling and climbing.

Since it must be recognised that the lower limbs serve another very important function in regard to the posture of standing, which cannot be dealt with as entirely distinct from walking, the upright posture position will be studied in its various attitudes of standing, sitting, riding and kneeling.

The occupational factors which cause anatomical and functional changes in the parts and tissues constituting the locomotor apparatus are numerous; this is more particularly the case as regards the various positions the human machine is forced to assume in order to effect certain kinds of work. In addition, the lower limbs collaborate with the upper limbs, acting as complementary structures; by this association are set going those actions and reactions which are necessary under various contingencies in order to bring about human activity in the complicated field of numerous industries. They may thus be influenced harmfully either through the working environment or the material and tools used, or the position required and maintained by technical needs, or yet by fatigue due to work of long duration or calling for short but intense, action of large groups of muscles.

As regards industrial accidents, the lower limbs rank close behind the upper limbs from the point of view of the frequency of injuries due to violent causes; on the other hand, as regards occupational diseases, they come some way after the upper limbs, owing to the fact that they escape the harmful effect of numerous injurious factors, associated with tools or working material with which the hands — the special organs of human activity — must necessarily either come in contact or be closely associated. Nevertheless, the organs of locomotion are at least equally affected by the changes effected by the influence of certain harmful occupational factors.

1. — Locomotor Apparatus

Attention will here be confined merely to a simple enumeration of occupational injuries of the locomotor apparatus. As most of these conditions are described in other articles, such as "Agricultural Labourers", "Bakery Industry", "Pottery Industry", "Rope Works", "Boots and Shoes (Manufacture of)" and "Iron, Pig Iron and Steel Industry".

(a) Affections due to conditions under which the work is carried on, and exclusively situated on, or having symptoms chiefly affecting, the locomotor limbs, are not numerous, and in general are due to injurious influences which act simultaneously on the whole body, such as high and low temperatures, or humidity.

Whereas high temperatures rarely cause localised affections, yet they may make their effects felt, especially on the feet, by causing excessive secretion of sweat ("hyperhydrosis"), e.g. blast-furnacemen, metal workers employed at rolling mills, glassworkers, stokers and engineers on board ship, even those without stockings and with wooden shoes), and soldiers after long marches. Constitutional predisposition generally favours this excessive secretion, which is localised by preference to the sole of the feet and to the interdigital spaces.
The sweat has a nauseating odour due to the ready decomposition of the fatty substances which it contains; it frequently causes a swelling, with softening and maceration of the skin, which takes on a whitish or dirty grey colour with eruptions and rhagades. This dermatitis may spread and lead to the formation of ulcerations and actual sores with all such recognised complications of infected wounds, as lymphangitis and distal adenitis.

In the same way, low temperatures in working places, in addition to their effect on the whole body, attack particularly certain parts least protected from the cold, such as the ears, nose and feet.

As regards the feet, cold acts on the peripheral circulation and nerve endings, causing a series of changes which range from the most simple and well-known erythema pernio to the most severe form of frost-bite and even to gangrene. In cold water, the extremities of the toes, may extend to the feet and encroach on the legs; it may even lead to death, chiefly as the result of general septicaemia.

The local effect of cold causes, in the first place, vaso-constriction — follows by vaso-dilation, characterised by a sensation of heat and a peculiar scarlet-red coloration, with cutaneous oedema, accompanied sometimes by phlyctenules containing sero-sanguineous fluid. If the condition does not stop there, vascular thrombosis occurs with arrest of the circulation, complete anaesthesia and dry gangrene of the tissues, which may extend along the limb with a margin of delimitation well defined from the normal tissues. The local action of cold may be further modified by conditions individual to the patient, and by such other factors as immobility, humidity, and tight shoes.

In addition to workers who are employed in cold, damp surroundings, mountain guides, soldiers and those who are employed on refrigerating apparatus are also liable to be affected by low temperatures.

The injurious effects of heat and cold may be associated with and increased by that of moist surroundings, in which the worker is compelled to work with bare feet. As an instance may be mentioned work in ricefields, where, during the weeding season, the temperature of the water varies between 20° and 45° C. After prolonged immersion of the legs, at the end of a day's work, the women workers present a condition of cutaneous hyperaemia, with lowering of the tone of the vessels and of all the soft tissues, so that in some cases— the skin has a macerated and somewhat oedematous appearance. (See article "Rice").

When a worker has to work with bare feet in cold water, as for instance in rivers, he is liable to a form of vasomotor neurosis. A condition of oedema of the extremities is then found; the toes can only be moved with difficulty and are pale and cold; a sensation of tingling is followed after a few hours by a sensation of heat and pain; the toes become red and sometimes a violet colour. This attack, which resembles Raynaud's disease, leaves forms of easily cured erythema pernio on the toes for some hours; it is due to the action of cold water on the sensory nerves of the skin; it causes a reflex vasomotor spasm with consequent paralysis of the vasomotors. Men employed in retting hemp and flax who work with their legs mostly immersed in water suffer from it; they are often affected with erythema pernio, which, from the extremities of the toes, may extend to the feet and encroach on the legs; it may even lead to death, chiefly as the result of general septicaemia.

The continued effect of cold on the feet is a source of frequent illness, without the occurrence of any local affection of the lower limbs (Branchle).

Work with bare feet in muddy places, such as excavations, and in the preparation and transport of clay, deserves special mention. Where ankylostoma is present in such ground, the legs may become the portal of entry for the parasite into the human system (Loos). Miners and gardeners are liable to contract ankylostomiases in this way.

All those who work with bare feet may be affected by such other forms of disease as dermatoses, eczemas, excoriations and ulcerations. The wounds, which may give rise to serious complications, and notably to tetanus, are numerous. Bites from leeches are quite common among those who work in the water of rivers and rice fields, and among peasants employed in hay-making and working in bare feet snake bites are not very rare.

Then again, certain forms of neuritis are due to rheumatic causes, e.g. ischialgia, met with amongst miners, stevedores, carriers, stokers and engineers, and certain forms of myalgias common among the same groups of workers and localised to the internal muscles of the thigh and calf.

The statistics of the English Ministry of Health emphasise the frequency of
cases of chronic rheumatism, especially in the forms of lumbago, muscular rheumatism and brachial neuritis. Llewellyn has called attention to the fact that cases of rheumatism are also common among women, and that almost one-sixth of the payments for sickness insurance are for cases of rheumatism among insured workers.

Among gardeners forms of rheumatism attain as high a figure as 25 per cent. of all cases of sickness (Hoffmann).

Etienne Martin and Juvin consider that a severe injury to a vertebral column, affected with old rheumatic lesions in a latent state, may cause the fracture of rheumatic neoformations and lead to a chronic vertebral arthritis with constant or intermittent pains.

(b) Affections arising from materials used do not often concern the lower limbs, because the physical action, or, as in most of the cases, the chemical action of any irritating substances — powders and liquids — used in the industries, seldom comes in direct contact with the lower limbs. The lower limbs, however, do not escape the general effect of the principal industrial poisons, e.g. lead, mercury and arsenic.

It is well known that lead paralysis almost always attacks the upper limbs and by preference the right; but it may sometimes occur, even primarily, in the lower limbs. In this case paralysis affects the external popliteal branch of the sciatic and chiefly the lateral peroneal muscles, the common extensor of the toes and the extensor of the great toe, the anterior tibial muscles not being as a rule affected. Sometimes, also, the posterior muscles of the leg, the adductors of the great toe, the foot muscles, the lumbricales and even the triceps cruris may be affected, either separately or as a localisation of a generalised condition.

In mercurial poisoning the lower limbs do not escape. Workmen affected by it complain of a feeling of weakness in the legs; they easily become tired and have a staggering walk. Sometimes, the disordered gait is due to a polyclonus rather than to weakness.

In arsenical poisoning paralysis caused by neuritis may be also found. In connexion to plumbism, occupational arsenical poisoning chiefly attacks the lower limbs and particularly the extensor muscles — through the external popliteal branch of the sciatic nerve — at their distal parts, the toes, and usually on both sides. Muscular atrophy quickly develops in the paralysed muscles, and there are constant disorders of sensation, these being prevalent in the paralysed areas in the form of violent and lancinating pains. The electrical reactions and tendon reflexes are the same as in lead poisoning.

Powdered mother-of-pearl (see that article) causes a specific disease of the bones, multiple recurring osteitis, which is seen in mother-of-pearl turners, more particularly among young workers. It affects the bones in general, and especially the long bones of the upper and lower limbs. Klein has described a form of osteomyelitis localised to the bones of the leg occurring among the jute spinners of Vienna, which is attributed by other experts to the effect of different factors (see article "Jute").

(c) Since working tools are rarely worked by the lower limbs, occupational diseases of these limbs from the use of tools are few.

There is not found on the lower limbs what corresponds to the occupational callosities of the upper limbs, caused by the reaction of the skin to irritating stimuli; but there is however noted the result of reactions to the influence of tools which cause irritation on some particular area of the limbs, either in the subcutaneous cellular tissue, or in the muscular tissue, or even in the skeleton. Here may be instanced the cobblers' callosity, situated at the upper edge of the rotula, circular in shape, in segments of a sphere; it is due to hyperplasia and hypertrophy of the cellular tissue of the zone against which the cobbler places his last and upon which he hammers the sole or the shoe. A small tumour, almost similar, situated at the middle third of the thigh, is found in workers who use pneumatic hammers. It is caused by the hammer, as it rests on the thigh, subjecting it to numerous minute vibratory shocks.

Reference must also be made to (i) a bony tumour due to thickening of the periosteum of the crest of the tibia, in its middle third, which occurs among miners in the Elbe district; these men are in the habit of resting on the crest of the tibia a kind of basket, into which the mineral falls when it is loosened (Mori); (ii) exostosis of the first metatarso-phalangeal joint of potters who use the Talo or pedal-driven wheel; it is caused by the continual blows which the potter gives with the internal surface of the foot, especially with the metatarsophalangeal joint of the great toe, to the pedal of the wheel to make it revolve (Pieraccini); (iii) thickening of the first metatarsal by osteo-periostitis occurs among the potters of Sardinia; it may be caused by the
action of the wheel, but even more likely by kneading the clay, which is done sometimes with the heels and sometimes with the sole of the foot, especially with the first metatarsal (Marcello).

Exostoses have been noted at the level of the digital tendons (joints of the back of the hand, especially at the base of the fingers, or on the palmar surface) in violinists.

Thickening of the convex part of the left collar bone has been noted amongst these artists. The collar bone also shows a ridge or depression due to the lower edge of the instrument (violin).

Violinists and leaders of orchestras also suffer from flat foot, and a convex deformition on the right side of the spine (scoliotic), which in time develops definitely into scoliosis.

All these affections originate in the same way. Innumerable minute consecutive shocks set up in the tissues a reaction to the irritation, which varies according to their histology; thus a tumour made up of connective and fatty tissues results if the reaction occurs in subcutaneous cellular tissue; while an osteo-periosttic formation develops if the reaction occurs in the periosteum or bone (Mori).

Mori, in an investigation into minute injuries to bones and anti-algic contractions, found that a direct or indirect contusion on an articular region may be followed by an osseous lesion either immediately or subsequently. The hypothesis of a lesion to the skeleton must not be excluded on account of the slightness of the injury, the absence of clinical signs, or of a favourable development; a radiological examination should be made in all cases of a para-articular injury at the commencement of the trouble.

(d) Affections caused by constrained attitudes and positions may occur in a workman who, during or on account of his work, is compelled to adopt a particular position of the trunk, and is often compelled to place his lower limbs in a position to correspond to the said position of the trunk.

Whatever these working postures may be, when they are maintained day after day and for long hours at a time, even those differing in but a slight degree from the natural static positions of the body, in the end lead to anatomical changes, and, in consequence, morphological and functional changes of the locomotor apparatus, especially when such other factors come into play as the nature of the work, sex, age, loads and special movements, all of which favour the development of such changes.

Arthrosis of the knee, of mechanical origin, following upon excessive industrial activity exacted from the static and dynamic elasticity of the segment in question, have been reported by Henschen (1929) among restaurant waitresses, bakers, waiters and soldiers.

The standing position is that required for most work. It is also the most natural and least injurious to the parts of the body called into play for maintaining that position, especially when it is interrupted by restful attitudes, which enable each limb alternately to relax from bearing the weight of the body, and more especially when some walking about occurs. But, if the rest period is insufficient, and if the upright position is accompanied by almost complete immobility, then the constrained upright position leads to conditions which favour the development of circulatory disorders and morphological changes in the extremities. These disorders become manifested as varicose conditions (see article "Occupational Diseases: Circulatory System", Varicose Veins).

The upright position also has an effect on the skeleton where there are other factors at work. "Bakers' sore leg", formed by a genu valgum on one side and a genu varum on the other, is well known; this last and other similar deformities are now however very rare, and are generally only historic souvenirs.

In the Prague clinic, out of 76 cases of genu valgum, or "bakers' sore leg", that were operated on in 1910, not one of the patients had a sedentary occupation. Among neighbours and heavy work Manz and Hofmeister have reported a deviation of the femur known as coxa vara. From the fact that it is met with frequently among agricultural labourers — 41 cases out of 79 — this condition has been called "peasants' leg".

Flatfoot originates from two principal factors — adolescence and occupation. Adolescent apprentices, employed on fatiguing work which requires the upright position for prolonged periods, easily incline to flatfoot; and the condition is found to occur with even greater frequency where the work is done in bare feet or in low-heeled shoes. Flatfoot is found among porters, barmen, sailors, potters working the wheel, guides, and soldiers.

Tillaux considers that flatfoot is due to fatigue of the peroneus longus, which in the upright position contributes to the resistance and solidarity of the plantar arch. When the weight
of the body on the plantar arch is prolonged to an exaggerated extent it
causes lowering of the anatomical constituents of the foot — osseous, lig-
amentous and muscular — and the lateral peroneus longus, which defi-
nitely holds up the plantar arch, becomes fatigued, the ligaments of the leg of the tarsus relax, the bones themselves slip one upon another; and, by the wearing down of the articular cartilages, a definite flattening of the plantar arch is established. The essential origin of flatfoot is then disproportion between the weight and the resistance (Hoffa).

Kaup has stated that the frequency of flatfoot among the young workers of Munich reaches the high percentage of 26.75, including slight cases, whereas the examination of recruits in the same town showed only a percentage of 0.6. Among the pupil teachers of the secondary schools, the number of cases of flatfoot increased during the three years of teaching and practical work; among barmen it varied from 18.95 to 69.23 per cent., and among bakers from 15.38 to 48. Among apprentice erectors of machinery, on the other hand, the frequency of flatfoot somewhat diminished.

Opitz, at Brunswick, found in the army 12.1 per cent. of flatfoot, whilst among barmen and bakers the percentages were respectively 25.6 and 22.

Talgia (painful heel) and tarsalgia are also to be attributed to prolonged standing.

Talgia, caused by compression and injury to the heel, in the upright position and on the march, affects the subcutaneous cellular tissue. It may appear in an acute form, but most often it has a chronic course and leads to atrophy of the adipose tissue of the cushion situated at the tuberosity of the calcaneum, with a preference for the right foot (Rivalta).

Tarsalgia (also called Morton's disease), or active contraction of the walking muscles, is common among porters, barmen and chiefly among adolescents, especially those growing quickly. It starts with a sharp pain at the middle of the sole, this being felt at the commencement of the step, when the anterior metatarsus rests on the ground to bring the body to the forward position; the pain then becomes continuous during the whole phase of weight-carrying; next it spreads; but it always remains most acute at the highest part of the arch. The painful phase is followed by a marked flattening of the plantar arch, and little by little a reflex contraction of the muscles occurs which prevents walking; and in the end there is the permanent formation of flatfoot. The disease has three stages: pain, spastic contraction, and definite morphological changes. It has been variously described as an alteration either of the articulations, or of the intermetatarsal segments, or of the bones (Bonomo).

With persons who remain for long periods on horseback, such as riding masters, jockeys and men who look after herds, the thighs and legs assume the well-known bow shape, which is also found among workmen who adopt during work the position of a cavalry man, e.g., knife-grinders who use electricity for driving the wheel and work sitting astride a seat with thighs and legs apart (Berlucci); saddlers, who work while keeping the same position astride a small model horse; and basket makers seated astride a stool.

Riders also suffer from a callosity on the heel, due to injury by blows from the saddle, myositis of the adductors, described by Ramazzini; a serous bursitis of the bursa on the internal side of the knee, upon which falls most of the friction between the knee and the saddle; myositis of the adductors, described by Billroth, among old light cavalry soldiers and cavalry recruits and represented by a typical osseous neoformation, which develops on all the adductors of the thigh, especially on the middle adductors; this condition arises from numerous minute contusions.

This neoformation has been regarded either as an ossification of the interfibrillar connective tissue of the periosteum (periostogenous theory), or as a degeneration of the muscle fibres with infiltration of young cells and transformation into cartilaginous tissue, which later becomes osseous (Havemann). Osseous neoformations may be met with among cavalrymen, as the result of the same mechanical minute contusions, in the vastus externus of the left thigh, due to injury by blows from the sword while the horse is galloping (Ludwig), on the pectineus (Josephsohn) and on the iliacus externus (Sangalli; Rivalta). Among riders is likewise found an insufficient functioning of the adductors due to contraction of the thighs.

In some trades the worker is compelled to adopt a kneeling position, crouched or with the body bent. The kneeling position adopted by domestic servants, parquet floor cleaners, floor layers, nuns and monks frequently causes, in addition to a cutaneous...
thickening of the front of the knee, a 
hygroma of the prepatellar bursa with 
the risk of suppuration supervening 
(see also "Miners' (Coalminers') Dis-

cases", Beat Knee).
The bent position of the body causes 
very important affections among women 
working in the ricefields during weed-
ing, reapers and mowers using the 
scythe, transplanters of turnips, potato 
gatherers, asphalters, parquet floor 
cleaners, and workmen who lift metal 
pipes. Thus, for instance, varicose 
veins are often caused either by any 
position which forms an obstruction to 
the return of the venous blood, or 
from the absence of movements of con-
traction and relaxation of the muscles 
which assist the return circulation.

Peripheral nerve affections, both 
pareses and paralyses, have been de-
scribed in the case of these workers, 
which have been attributed to compres-
sion of the nerves on hard surfaces, 
or to stretching of the nerves. They 
are found in the peroneal and pos-
terior tibial areas (Govers, Pieraccini) 
as a consequence of the stretching and 
compression to which the nerve is sub-
jected between the tendon of the biceps 
and the head of the fibula, e.g. among 
buckroo gatherers.

(e) Affections due to excess of work 
may be caused either by long hours, 
causing fatigue and exhaustion, or by 
putting the reserve muscular energies 
into play for a short period in order to 
expend unusual force so as to over-
come an abnormal resistance.

Excessive muscular work may lead 
to tumefaction of the muscle fibre, to 
fatty degeneration, to the disappear-
ance of striae, and to atrophy.

Excess of muscular work performed 
by the lower limbs is found equally 
among persons who are a great deal on 
horseback and among those who 
make long marches on foot; it also 
occurs among workmen who are 
obliged to use the feet and legs in order 
to work an instrument or a machine, 
for instance, knife grinders, organ 
players, tailors using pedal sewing 
machines, potters and turners.

Such excess of work may manifest 
itself in affections of the muscles, 
tendons, bones, joints and nerves; 
these will now be rapidly reviewed.

Myositis, caused by exhaustion, con-
fined to a muscular group which has 
undergone a long period of work, is 
characterised clinically by pain and a 
slight swelling of the muscles, which is 
sometimes accompanied by slight rises 
of temperature. According to some 
experts, it is due to simple exhaustion 
in consequence of a series of numerous 
contractions; according to others, it is 
due to insufficient elimination of the 
local products of organic combustion.

This strictly occupational affec-
tion is not common; it has been met with 
in an organ player who was obliged 
to contract his muscles to use the 
pedals from six to eight hours a day 
(Strumpell). It is quite often localised 
to the muscles of the calf in the case 
of recruits accustomed to long marches 
(Hayem, Strümpe1, Silva), and to the muscles of the thighs in 
the case of riders. It occurs in an 
acute form, accompanied almost al-
ways by fairly severe pain which dis-
appears completely in some days. 
There sometimes remains, however, a 
fibro-sclerotic induration of the muscle 
affected.

The occupational forms with slow 
development are much less painful; 
they develop slowly and usually lead 
to a hyperplasia of the connective 
tissue, causing in turn permanent 
functional damage which limits the 
movement of the muscles. Simple 
atrophy of muscular fibres may also be 
found.

The rheumatic factor often con-
tributes to cause, or at least to favour, 
this morbid condition.

Tenosynovitis or tenovaginitis from 
over-exertion, also called crepitating 
tenosynovitis from one of its charac-
teristic symptoms, is well known in its 
clinical aspect; it is due to an inflam-
atory process confined to the tendon 
and its sheath, which usually gives rise 
to the production of fluid.

The development may be slow, but 
mostly the condition develops in a few 
hours. It is the result of irritation 
caused by rapid and numerous move-
ments of the tendon in its sheath, and 
occurs generally following long 
marches and rapid or prolonged mani-
pulation of working tools.

The tendons in the lower limbs 
affected in consequence of muscular 
movements are numerous; the 
tendo Achilles is the most commonly affected, 
from above its point of attachment up 
to the area of muscle insertion, in the 
case of persons who walk much, women 
who work pedal sewing machines, 
knife grinders, turners, potters, cyclists 
and mountain guides. At other times 
the tendon is damaged exactly at its 
point of insertion — Albert's achillo-
dynia, which is different from trau-
matic achillodynia, this last being 
caused during walking as the result of 
the boot rubbing on the heel. Finally, 
inflammation of the serous bursa (burs-
itis) may occur at the heel under the 
point of attachment of the tendon 
(Rössler).
The tendon sheaths round the ankle, those of the lateral peroneal muscles, and the common extensor and the anterior tibial, may also be affected by prolonged marches and in persons unaccustomed to walk long distances and rapidly.  

Circumscribed inflammatory processes in the form of periostitis and osteoperiostitis have been described among soldiers, following upon exhausting marches, and have been attributed to fatigue (Laub). The lesion is generally situated at the upper third of the tibia, where it occurs as a painful swelling (Casarini); but it is also situated, although more rarely, at the lower third of the tibia, at the malleoli and the bones of the foot (Toussaint, Schwartz, Manceaux). The affection develops in a slow, dull manner causing pains and giving rise to the formation of fluid; it is reabsorbed leaving plaques of hyperostosis corresponding to the insertion of the muscles, especially of the solear muscle (Leistendorfen), of the common flexor of the toes (Hérol), and of the popliteus. This form is usually found in young persons at the period of the formation of bone tissue (Rivalta).

Stretched foot (in Italian "piede gonfio", in German "Füssgeschwulst") consists of oedema of the front of the foot and is peculiar to infantry soldiers and especially to recruits.

Osteoperiostitis of the metatarsals, which has been studied by Weissbach, Pauzat and Poulet, and radioscopically by Thalwitzer particularly, is characterised by fusiform bony prominences from 4 to 5 cm., extending from the base of the metatarsals along the insertion of the interosseus muscles. An intense uniform shadow without formation of fluid; it is reabsorbed leaving plaques of hyperostosis corresponding to the insertion of the muscles, especially of the solear muscle (Leistendorfen), of the common flexor of the toes (Hérol), and of the popliteus. This form is usually found in young persons at the period of the formation of bone tissue (Rivalta).

The lesions caused by quick, unforeseen, effective, but unco-ordinated contractions which exercise a pull on the antagonistic muscles in a state of passive contraction or of posture are more common.

This mechanism starts simple muscular distension, characterised by intense pain (simple myalgia) which heals readily, or a laceration of the muscle which is easily diagnosed by characteristic clinical signs; the adductor muscles may be affected in riders, commonly those on the front of the right thigh, or the calf muscles, giving rise to "coup de poing" (whip-lash) or pain from sudden contraction of the leg muscles. Sometimes the effect of the muscular pull does not spend itself in the muscle, but affects the skeleton at the point of attachment of the muscle, from which may arise

fatigue (Ferrier). During marching there is a broadening of the foot to reduce the vibrations and increase the stability of the body; at the same time the reflex contraction of the muscles is opposed to an excessive extension of the foot. But when, in consequence of excessive burdens and reduction in the energy of the foot muscles, caused by fatigue, these muscles do not respond adequately to their functions, extension occurs, and fracture may occur on a point of the arch, where the maximum of thrust and the minimum of resistance is concentrated. This fracture is usually found at the second metatarsal of the right foot; it is more likely to occur when running, jumping, or walking on uneven ground, or going uphill.

Among other painful conditions also attributed to fatigue are occupational cramps, which are, however, much less common than in the upper limbs, but may occur amongst dancers, knife-grinders and cyclists.

Fracture of the metatarsals is also attributed to arduous marches aggravated by burdens (Weber) and by

1The statistics of the Swiss National Accident Insurance Fund show that of 522 cases of bursitis, 52 per cent. were situated at the knee (on the right side more often than on the left); 42 at the ankhles — on the left side more than the right; and 8 per cent. were distributed over other parts (Wehrli).
transverse fracture of the patella, or even detachment of a bony layer from the calcaneum at the point of the insertions of the plantar ligaments.

Finally, always as the result of an effort with unco-ordinated movements, hermia of the muscle may occur either of the large adductor in the case of riders (Larrey, Dauve, Baudin), or of the gemell. The enveloping aponeurosis is torn violently and the underlying muscle makes the hernia; it becomes manifest either as a tearing of the sheath of the muscle, or as a swelling, depending on the period of contraction or relaxation of the muscle concerned.

2. — UPPER LIMBS

As regards the upper limbs it must be recalled that the influence of the occupation may manifest itself by an aggregate of changes. Thus Brezina and Lebzelter, relying upon an examination of 1,200 persons, found that manual labour exercised an influence on the breadth and thickness of the hand; the root of the hand is little affected, and, in the same way, the length of the hand does not seem to show any change. Quarelli (1889) has described luxation of the phalanx of the thumb among the dairymen of Piedmont employed in milking cows; Poncet, the hooked hand of glass-makers; Vernes, a contraction of the fingers in a state of flexion among nail-makers; Teleky, a similar deformity among basket-makers; A subluxation of the wrist, known under the name of "Madelung's deformity" may be met with in young laundry maids and grinders; Dupuytren's contraction, or contraction of the palmar fascia, has been described among English machine-lace makers (Collis) and is met with among other workers whose palms are exposed to frequently repeated injuries.

As regards bony lesions, Düttmann reports seven cases of necrosis of the lunar bone in workmen employed on difficult work; on the other hand, a new formation similar to osteomas of cavalrymen has been described in soldiers in consequence of the recoil of the rifle, the position of the injury being the deltoid. Another common occupational lesion is fracture of the lower end of the radius among chauffeurs, due to back-fire when starting the motor with the crank-handle.

Among muscular lesions may be mentioned atrophy of the muscles of the thenar area in workmen obliged to execute frequent repetition movements (Teleky); muscular atrophy of the shoulder and arms among tram-drivers (Schwarz); rupture of the muscle fibres of the right deltoid in blacksmiths (Layet); that of the tendon of the short portion of the biceps in laundry maids (Weber); rupture of the long flexor of the thumb at the point of its muscular insertion, in a workman employed in coupling railway carriages (Gontermann); muscular atrophy from the use of pneumatic tools (Beiniker).

Tenosynovitis of the wrist and crepitating tenovaginitis have been observed in workers at various occupations requiring a permanent effort from the wrist, e.g. coal-miners, laundry maids, stonecutters, pianists, carpenters, brick-makers and agricultural labourers.

Contractions of the tendons have been observed in cases of chronic lead paralysis. Further, ischaemic muscular contraction of the forearm has been reported following upon confusions.

3. — THORAX

In connection with the thorax, rickets has been described, especially in young workers. In some trades the effects of this disease pass off in the course of the occupation; thus, for example, among machine erectors, the frequency of the rachitic symptoms decreases from 30 to 8.7 per cent.; among barmen, from 49 to 14; and among tailors from 42 to 3.1 (Kaup).

Thoracic deformities, constituting what may be called occupational stigmata, have been observed in some occupations wherein the workmen maintain injurious positions, such as shoemakers, tailors, turners and boatmen, with very exaggerated right subclavicular fossa.

In the case of turners the right half of the thorax is reduced in its transverse diameter and forced backwards as compared with the left side. The muscles on the same side, especially the serratus magnus, are on the contrary unusually well developed.

Asymmetry of the thorax has been found in glass blowers and miners (Mazzi).

4. — VERTEBRAL COLUMN

Deformities of the vertebral column as a consequence of occupation have been described in apprentices by Elsener; scoliosis among stone-carriers, localised in the dorsal region and showing a convexity to the left by Golebiewski, and by Mazzi among agricultural workers employed in sulphuring vines. This deformity ceases to be noticeable...
As regards the treatment of flatfoot, the choice of suitable boots is of first
importance (Conn, Bradford, Bettman). The German Sickness Insurance Offices make frequent use of supports (Einlage) which help to maintain the plantar arch. This treatment cannot be of benefit in certain cases where the application of the support encounters opposition: with patients who do not wish to be cured for fear of losing their pensions; with patients who, after a preliminary failure, refuse to persevere in the treatment, being persuaded that it is useless (Blencoe).

LEGISLATION

In the Netherlands, there is compulsory notification of inflammation of joints, of musculo-tendinous sheaths, of the skin and subcutaneous cellular tissues for each of the following occupational classes: brickmakers, woodcutters, coal-miners, peat-diggers, boiler-makers, incandescent lamp makers, printers, flax workers, herring gutters, iron founders, glass-makers, carpenters, mat-weavers, laundry workers, hide-sorters, gut-cleaners, ironmongery factory workers, workers in building yards, shipbuilding yards, blacksmiths, shops, and sugar refineries, horticulturists, makers of clogs, oyster pickers, fishermen and packers of herring in barrels.

Synovial effusion is compulsorily notifiable for each of the following categories: at the knee: masons, thatchers, paviors, makers of rush mats, coal-miners, workers in shipbuilding yards, agriculturists and horticulturists, layers of stone flags and domesticities; at the elbow: coal-miners and glass-polishers.

Occupational lesions of bones, muscles and joints receive in some countries the compensation benefit which is given for accidents: subcutaneous cellulitis of the hand, subcutaneous cellulitis or acute bursitis of the knee or elbow in workmen employed on mining, in Canada (Alberta, British Columbia and Nova Scotia), Chile, Great Britain and Northern Ireland, the States of Minnesota and New York, Queensland, Venezuela and Western Australia; tenosynovitis and prepatellar bursitis, primary tenosynovitis characterised by a passive effusion or crepitation in the tendon sheaths of the flexors or extensors of the hand in workmen whose work involves movements or vibrations frequently repeated or continuous pressure, in the State of Ohio; inflammation of the tendon sheaths, arthritis caused by work, in Japan; chronic inflammation of the synovial membrane of the knee and elbow in stoneworkers, slaters, pontoon men and miners; chronic inflammation of the tendon sheaths among women ironers and women packers of parcels; flat-foot, "bakers' leg", etc. (overloading the joints), among leaders, weavers, messengers, dentists and sellers in the U.S.S.R.; occupational diseases of the tendons and muscles, in Chile; of bones, muscles and joints due to work with pneumatic tools, in Germany; diseases of the joints and muscles due to poisons (lead, etc.), in France and in countries which adopt the Anglo-Saxon formula (first column) or that of the Convention of 1925; for diseases of the bones caused by radio-active substances see that article.

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Prof. G. Pieraccini
(Florence).

Urogenital System


All the uro-genital organs are exposed to occupational injuries, and account should be taken of the fact that repercussions from them affect not only the individual but also the race. The uropeiotic and genital systems are easily affected and, although the diseases affecting them can be easily diagnosed, their etiology is difficult to
explain, because of the complications brought about by the role played by injurious bacteria.

Among affections of the kidney, of which all kinds occur, distinction must be made between primary and secondary effects. Among the primary occur simple albuminurias, temporary elimination of albumen which Strauss describes as "aneuphritic albuminuria." Such albuminurias, which are found after physical effort, especially among sportsmen and soldiers, have no particular importance, although Leube has been able to find them in 10 per cent. of the cases examined.

More importance is to be attached to haemoglobinurias resulting from marching, which O. Klein considers to be due, as well as haemoglobinurias from cold and orthostatic albuminurias, to the same cause, namely, circulatory disturbance of the kidneys, set up as reactions by walking and an upright position in persons affected with lorderosis as by chilling of the skin.

Some kidneys are predisposed to haemoglobinuria as in paroxysmal haemoglobinuria; under the influence of a cold spell there is a clear clinical picture characterized by haemoglobinuria and fever, which, in the absence of a positive Wassermann reaction, presents certain cytological and chemical modifications of the blood (increase in the resistance of the red blood corpuscules to hypo-tonic saline solutions, increase in the number of red and white blood cells of the haemoglobin and in the sugar content, etc.).

These cases are rare, but there ought to be other less precise intermediate cases, the study of which would be desirable as they might throw light on the relation between the influence of cold or humidity and nephritis. In the pathogenesis of nephritis from cold dependence has to be placed on hypothetical probabilities and no proof is available. Thanks to the researches of Eppinger and O. Möller, it seems to be established that the capillaries constitute a single system and that glomerular nephritis, for example, is only a partial manifestation of a malady affecting the whole of the capillary system. At the point where it acts, cold causes a vaso-constrictive effect with subsequent vaso-dilatation, and can thus set up reactions in other parts of the system.

It is well known how sensitive the kidneys are, especially when a predisposition to circulatory affections exists, and how, in certain well-known conditions of exposed parts, cold may bring about the grave clinical symp-
toms of paroxysmal haemoglobinuria. Thus it will be readily recognized that permanent functional damage to the kidneys may result from the prolonged and repeated influence of cold and humidity. While admitting this, it must not be forgotten that, from the point of view of infection, a certain predisposition plays an important part.

It is interesting to note that persons who are engaged in occupations most exposed to inclement weather conditions, such as agricultural labourers, builders, etc., are less subject to maladies caused by cold than are those who carry on work under sheltered conditions, as for example, tailors, who are particularly sensitive to cold.

The relation of cause and effect is thus less precise in these cases, and the same can be said of the relation between sore throat of occupational origin and nephritic foci. It is an established fact that such nephritis can be brought about by an angina in the throat, although no statistics exist to prove it from the point of view of industrial pathology.

The inhalation of toxic dusts must be particularly considered because they may set up serious irritation of the buccal mucous membrane and consequently severe sore throat. Among these dusts the most important are those of certain wools (alpaca, goat-hair, camel-hair, and common Asiatic wools, etc.); sharp particles of horn and ivory; hemp dust and organic fungi (from contact with the fungus Boletus ignarius); wood dust (mahogany, maple, logwood, sandalwood, etc.); dust arising from gathering the hop harvest; carpet dust, dust from hair (for cleaning brushes); leather, tortoiseshell, siliceous dust (stone cutters, glaziers, often polishers of precious stones like amethyst, agate); marble dust; dust produced in the manufacture of glass paper and emery paper and upholstery work; dust from metals, verdigris, tobacco, etc.

In these cases there is the possibility of nephritis secondary to an angina of the throat of this kind, and this is worthy of close study.

A secondary nephritis may constitute a syndrome accompanying industrial infectious diseases, as, for example, erysipeloid conditions, generalised or anthrax septicemia. A little more is known as regards the relation between traumaism and kidney diseases, because the latter are usually the result of external violence, such as a direct contusion in the region of the kidneys or an impact of the kidney
against processes of the vertebral column or lower ribs. The injury may cause disturbance or destruction of the kidney substance, rupture of the capsule or the pelvis, of the ureter or the vessels. The clinical symptoms show themselves in collapse, rapidly progressive anaemia accompanied by haematuria.

Beside these grave lesions, the kidney can be displaced and the floating kidney thus created, with its often complicated symptomatology, presents problems of certain practical importance. It should be mentioned here that, especially in women whose work involves intra-abdominal pressure, the abdominal walls may extrude with enteroptosis and a floating kidney.

Estimation of the degree of incapacity for work caused by a floating kidney is often very difficult, because there is no criterion by which to determine it. Before evaluating troubles of this kind it must be remembered that a floating kidney may not only be accompanied by nervous trouble but also that already existent hysteria or neurasthenia may be aggravated by it.

It is a well-known fact that a floating kidney occurs more often in women than in men. According to Stern, it is not a question, in the majority of cases, of a normally well-adherent kidney but dislocation of an organ already movable or non-adherent. Such an insufficient fixation is met with more often in women than in men, often as one of the symptoms of a general enteroptosis.

Other kidney affections of a traumatic nature are, according to Stern, haematonephrosis, hydronephrosis, peri-renal haemotoma, pseudo-hydronephrosis, cicatricial stenosis of the ureter or pelvis. The French authors Castaigneawl and Rethory report also the occurrence of diffuse inflammatory processes of the kidney of a chronic character. In German literature acute and chronic traumatic cases of nephritis have been described, as well as very varied infectious diseases of the kidney such as diffuse, pyonephritis, pyelitis, pyleonephritis, etc. Finally, it is known that kidney diseases of this kind may be aggravated by injury, but it is not possible here to discuss more fully the relation between traumatism and the kidneys.

Kidney lesions due to the most diverse types of poisoning are very important and better-known. It should be remembered specially in regard to such forms of poisoning that they may be simple functional troubles without disease of the kidney properly so called, especially when some mechanical obstruction of the renal canaliculi is present, set up by blocks of haemoglobin formed under the haemolytic action of certain poisons. The obstruction may reach such a degree as to produce complete anuria, ending in death, with a picture of renal uraemia.

The number of poisons causing methaemoglobinuria, jaundice, anuria, etc., is very considerable. The following are the most important:

(a) Inorganic poisons: chronic acid, nitrous fumes, nitrates, potassium chloride, arsine, hydrogen, etc.;

(b) Poisons of the aliphatic series: hydrazines (diamines), nitroglycerine, amylnitrite;

(c) Poisons of the aromatic series: chlorobenzene, nitro-dinitro-, and tri-nitro-chlorbenzene, nitrobenzene, amido-benzene (aniline), phenaacetin, phenyl-hydrazine, trinitrotoluene, toluidine, nitrophenol, etc.

It is not yet certain whether these cause functional disturbances of a mechanical nature or if the haemoglobin, dissolved in the blood, acts also as a foreign albumen body, thus causing epithelial alterations in the renal canaliculi, and in this way alterations which are of longer duration.

The principal poisons which directly cause renal disease, often of a very serious type, are lead and mercury. Others, like cantharides, arsenic, turpentine and different tar derivatives, produce, in addition to epithelial degeneration, exudative processes and above all cellular infiltration into the connective tissues. On this matter Munk has stated that "extensive necrosis of the epithelium in the principal pyramidal tracts and fatty degeneration (infiltration?) of the epithelial cells of the right tubules is always found. These ulcerations I have also found in the kidneys of some munition workers, who, in consequence of some insufficiently-known cause, had died with symptoms of poisoning or pneumonia." The reader is referred to different articles in the Encyclopaedia for data concerning the toxic action of different products, and mention will here be restricted to indicating the general lines of the problem.

Fatty degeneration of the kidney is recognised as occurring as the result of the action of phosphorus (acute non-occupational poisoning), arsenic (acute and chronic poisoning), and carbon monoxide, as are likewise renal troubles due to the action of acids (su-
phuric, nitric, oxalic, salicylic, phenic, etc.), of which the majority, however, are of non-occupational character. It is the same in regard to chromic acid, which in cases of acute poisoning can set up very severe nephritis, while important statistics show that the industrial use of chrome has produced nephritis very rarely if at all.

Generally speaking, acids and alkanes do not play a very large part in the pathology of the uropoietic system. Grun, however, has stated that in a soap factory where strong perfumes, and chemical colouring matter and alkanes were used, he had observed some cases of chronic nephritis which he had attributed to the use of these colouring matters and the inhalation of alkali fumes. Other kidney irritants are tar, cantharidine, naphthamine, carbon bisulphide, turpentine, etc. The latter has special importance from the point of view of industrial pathology, as experiments have shown that 3 to 4 mg. of turpentine vapour per litre of air cause symptoms of poisoning in animals and renal irritation and, further, that important nervous troubles and other organic affections in man may result therefrom (see article “Turpentine”).

Arsenic trichloride, which is used in the explosive industry, and tetrachloroethane, used as a solvent — both of which may cause fatty degeneration of the kidneys — are of less general importance.

Alcohol should be mentioned in passing, as it cannot be considered as an industrial poison but rather as a dangerous product absorbed with food — unfortunately in excess — in the most diverse industries, because it has the power of apparently dispersing sensations of fatigue. It is, therefore, only to be regarded as an indirect industrial poison able to produce renal lesions.

The most serious lesions are caused by mercury and lead.

Mercury used in a large number of industries causes in severe cases nephrosis (necrosing nephritis) of the kidney and in slighter cases a picture of a nephrosis. The symptoms are revealed by the presence of a large quantity of albumen in the urine with all manner of cylindrical casts and fatty degeneration of the renal epithelium.

The sufferer has a rather ruddy complexion, slight swelling of the face and possibly a difference in his voice accompanied by high blood pressure or cardiac hypertrophy, but with oliguria or anuria with sequelae as the principal symptoms.

The other renal poison is even more frequent, namely lead — and, likewise, oxide of zinc, the similar action of which on the kidneys is less known — which sets up two forms of lead nephritis, namely, interstitial nephritis and the small arterio-sclerotic kidney.

On a basis of a thousand autopsies, Ophuels has tried to establish the relationship between saturnism and gout on the one hand and arteriosclerosis and arteriosclerotic nephrosis on the other. He found that among 30 cases of gout, 3 were probably caused by lead poisoning, and that all the gouty kidneys produced arteriosclerotic changes which were more or less marked. The opinion that saturnine gout is the sequel of saturnine kidney, as the result of which the damaged kidney is unable to eliminate uric acid, has been often combated, and so much the more so since the two affections are often met with together, without, however, being necessarily connected.

The small arteriosclerotic kidney is met with not only among lead workers, but also as an industrial injury more or less direct in all cases where physical and intellectual over-pressure is accompanied by excessive drinking, as is so frequently the case among business men, artists, officials, etc. Occupations carried on in the open air are subject to this which is found especially, on the other hand, among those engaged on work in cold rooms or in a cold and humid atmosphere when accompanied by heavy eating and drinking as in the case of butchers, brewers, underground workers (mines) and agricultural workers.

According to the British statistics in the Decennial Supplement of the Registrar-General for the years 1921-1923, the mortality from acute kidney disease does not show any definite relationship with the social position of workpeople. The Registrar-General’s tables of the minimum and maximum figures of chronic nephritis, distributed according to profession, are reproduced in the table on page 491.

Among the parasitic maladies the most important are those due to Taenia echynocosus and Schistosoma haematothium. This latter has very great local importance, because something like 80 per cent. of the fellaheen in the Lower Nile Valley employed in agriculture and gardening, or as fishers or workpeople, are unaccompanied by this malady which is found especially, on the other hand, among those engaged on work in cold rooms or in a cold and humid atmosphere when accompanied by heavy eating and drinking as in the case of butchers, brewers, underground workers (mines) and agricultural workers.

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on lesions such as cystitis, enteritis, urethritis, pyelonephritis, inflammation of the ureter, vesical tumours and stones. A classical description is that given by Goebel:

"Benign tumours in bilharziosis are in most cases tumours with granules arising from cystic cystitis, the origin of which is to be found in a proliferation of sub-epithelial connective tissue followed by epithelial proliferation. They may be compared to the small vegetative growths present in vegetative (proliferating) cystitis with this difference, that the epithelial proliferation in the large tumours never disappears.

"This participation of the epithelium to which the conservation of the tumours is perhaps due has its origin in prolonged mechanical irritation exercised by the eggs of bilharzia, without however excluding the possibility of an action of microbial origin. Perhaps the obstruction of the lymphatic passages and blood vessels by the massive accumulation of eggs in the sub-mucous membrane and muscles plays a part therein. The benign tumours are the direct consequence of infarcts in the vesical mucous membrane due to the eggs of bilharzia. The influence of decomposed urine or gallstones cannot be admitted in this connection."

"Besides granular tumours there is also met with a true neoplasia of benign type, a polyposis combined with bilharzian cystitis. It has not been possible to determine to what extent this neo-formation is due to an irritant inflammation of congenital predisposition. The historical details reveal close relationship between benign epithelial proliferation and an etiological action due to bilharzian cystitis.

"Malignant tumours constitute at least 50 per cent. of the proliferations observed in bilharziosis. They are in general and almost exclusively carcinomas and especially of a carcinoid nature. The genetic relationship between bilharzian cystitis and the development of carcinoma cannot be contested and is proved by statistics. Bilharzian carcinoma can be compared to the tumours occurring among paraffin and pitch workers, those engaged in the manufacture of aniline colours, smokers, etc. They do not, however, support the contention in favour of a parasitic origin of cancer. The epidermoidal (leucoplastic) or endodermal metaplasia of the vesical epithelium which occurs concomitantly with the tumours plays a decisive role in the formation of the carcinoid and of a mucous cancer of the bladder. Except over a few areas the carcinomatous epithelium is quite distinct from the pavement epithelium of the bladder. The cancer develops in the mucous membrane as a definitely isolated entity. In passing through the submucous and mucous, or more rarely the muscular tissues, the cancerous growth only englobes secondarily the eggs of bilharzia which are found in the peripheral layers of both striata and alveoli."

In the above description of Goebel the origin of the cancer is presented in such a clear way that it can be described as of an occupational nature.

The most important of the industrial diseases of the bladder are the tumours occurring among aniline workers. While referring the reader to the article "Tumours" for fuller details, it should be recalled here that since the observations of Rehn (1895) the number recorded up to the present time is pretty considerable. Thus, in the German chemical industry, up to 1926 some 250 cases of bladder tumours (Koelsch) have been recorded characterised by modifications of the vesical mucous membrane, accompanied by symptoms of irritation, dysuria, strangury and haematuria. The neoplasm may be either a papilloma or a malignant tumour which latter, in its turn, may be a secondary degeneration of the benign growth. Among the suspected causes are aniline, toluidine, xylidine, anisidine, p- and o-toluidine, benzidine, tolidine, etc. Other substances, such as Congo red, safranine, benz-purpurine, the
blue colours of rosaniline, have been held capable of causing proliferation of the vesical mucous membrane (see these articles).

Absorption of the toxic substance is considered to be by way of the respiratory tract and through the skin; the digestive tract playing an altogether secondary role. According to Nassauer, the chemical nucleus capable of engendering the harmful effect may be amino-benzine (aniline). The malady is met with especially among workmen employed inside the sheds of chemical factories. Cases, however, have occurred among persons living in the immediate neighbourhood of these factories (porters, canteen attendants, clerks, members of workers' families, etc.). The disease is fairly slow in its development and its appearance, on an average, takes place after fifteen years' duration of employment. Individual predisposition plays a part which ought to be borne in mind.

Besides aniline, arsenic has been thought to be a cause of neoplasms of the bladder. This view has been maintained by A. Hamilton as a result of observations made by Wignall, of Manchester. This last-named author has recently published (1929) some notes on cases of bladder affections, some accompanied by new growth, and others not, among workmen employed in the manufacture of a-naphthylamine (see that article) and other colouring matters of this group, which necessitated the use of arsenic. His cases numbered 20, of which 8 occurred between 1880 and 1910: 1 in 1914, 4 in 1918; 2 in 1924; 2 in 1926-1927: 2 in 1927 and 1 in 1928. Finally, Posner has described the case of a workman in the tar industry suffering from scrotal cancer (see articles "Tar", "Cotton", "Petrol" and "Tumours"). Posner, however, describes cases of atrophy of the testicle following chronic lead poisoning; on the other hand, men poisoned by this metal may beget children somatically and mentally weak. Thus Rennert has noted amongst the families of Hessian pottery workers, in addition to rickets, children with hydrocephalus and tonic and atonic convulsions ending fatally. Moreover, instances are given of parents, the victims of lead poisoning, having children who were idiots or epileptics or who suffered from hydrocephalus or convulsions, etc. This is comprehensible when it is recalled that lead acts injuriously not only on the male and female germ cells, but can also pass into the placental circulation and through the mother's milk.

In dealing with occupational injuries of the genital organs very clear distinction must be drawn between the two sexes. In man the only malady in general is that of scrotal cancer (see articles "Tar", "Cotton", "Petrol" and "Tumours"). Posner, however, describes cases of atrophy of the testicle following chronic lead poisoning; on the other hand, men poisoned by this metal may beget children somatically and mentally weak. Thus Rennert has noted amongst the families of Hessian pottery workers, in addition to rickets, children with hydrocephalus and tonic and atonic convulsions ending fatally. Moreover, instances are given of parents, the victims of lead poisoning, having children who were idiots or epileptics or who suffered from hydrocephalus or convulsions, etc. This is comprehensible when it is recalled that lead acts injuriously not only on the male and female germ cells, but can also pass into the placental circulation and through the mother's milk.

The female sexual organs are exposed to occupational risks in far greater degree than the male. Already from purely physiological causes, such as menstruation, pregnancy and suckling, the woman's resistance is diminished and rendered more receptive to injurious influences. Apart from the extremely probable alteration in the basic psychical functions of a subject which would repay closer study of it than has so far been made — the morbidity and mortality figures of the working woman show very high figures. The number of cases of sickness among working women according to Thiele is five to eight times more than that of the leisured class. Among these numerous maladies are those which
The occupational affections of the female generative organs are analysed in the article "Women's Work", to which the reader is referred.

The creation of what Hirsch might call a system of occupational gynaecology is altogether desirable and is required in the interest of the ever-increasing movement for the protection of women.

There remains to be studied a group of maladies often closely connected with occupational life, but which cannot be considered as industrial diseases: these are venereal diseases properly so called. The lessened mental and physiological resistance during puberty already mentioned, the common life of the two sexes, especially in factories, the absence of pleasure in the work done, which is often unduly mechanical, engender nowadays a tendency to alcoholism and accentuated sexual life. These conditions are still further increased by the employment of the mothers, employed as they are in industry, neglect the necessary supervision of inexperienced young persons. This state of affairs leads not only to an increase in sexual neurasthenia, but also to an increase in the risk of contracting venereal disease.

To the disease of the generative, digestive and other organs all contribute on the other hand to create such a state of things.

Apart from these considerations certain occupations predispose to a considerable degree to venereal disease. These are notably transport services (sailors, barges, etc.), night employment (post offices, hotels, transport, bakers, etc.) — occupations in which exposure to this risk is greatest. Certain authorities incline to the view that venereal disease affecting prostitutes should be given recognition as an occupational disease.

While cases of venereal disease may merely be regarded, as has been stated, as indirectly occupational, many cases of extra-genital syphilis are occupational in origin, e.g. syphilis contracted by medical men, nurses, midwives, laundresses or rag sorters who have handled infected material (see article "Syphilis"). In the past the most frequent instances of this character have been met with among musicians playing wind instruments and glass blowers. But contact with other articles, such as blowpipe pipettes, shuttle kissing, the habit of holding between the teeth nails which are kept in a common box (by bootmakers, carpet layers, etc.) have also given rise to buccal infections. The same is likewise the case even in regard to the use of brushes, chalk and feathers among painters, seamstresses, and office workers.

Acquired extra-genital syphilis is particularly common among medical men who, as a terminal action of the specific poison, are most liable to become the victims of locomotor ataxia and general paralysis of the insane. According to Trueb, the reasons for an unfavourable prognosis among medical men are: longevity and the conditions under which they have to carry on their profession which are a priori harder than in other occupations; the
injuries engenders a psychical and debilitating nervous change; and in cases where there is a neurotic tendency, as a result of overwork and exhaustion due to the hard work the medical profession entails, medical men suffer more than other classes both mentally and physically. Their powers of organic resistance are diminished and this fact together with impairment of force as regards healing and recovery may, as a terminal effect, bring on more or less rapid failure of the nervous functions.

On the other hand, there are countries (e.g. Algeria, Abyssinia, tropical Africa, rural districts in Central and Eastern Russia) which seem to be practically free from progressive general paralysis. The zone of the spread of this malady then is an index of the extent of the damage arising from intellectual life and a high degree of civilisation, for what has been said holds good equally of the occurrence of syphilis among all intellectual workers. The frequency of tabes and general paralysis in this professional class is not only favoured by the infecting agent, but also by the numerous occupational types of injury to which the central nervous system of intellectual workers are exposed.

From the foregoing it would appear that, in considering the origin of occupational maladies, account must be taken not only of the specific action of the professional damage, but also, at the same time, of the influence of environment in relation to diseases of the genital system, of the so-called secondary effects which are of importance as well as the primary injury. Those suffering from diseases of the uro-genital system may receive compensation where the substances giving rise to them presumably are scheduled under the Workmen's Compensation Act in force in the individual countries (see the article "Occupational Diseases: Definition and Compensation"). Certain lesions, however, figure in the list of scheduled conditions. Thus, for example, tumours of the bladder caused by amido-derivatives of the aromatic series are scheduled under the German Compensation Act. On the other hand, the British Schedule does not yet entitle victims to compensation. They are, however, statutorily notifiable in the U.S.R.R. Nephritis is compensatable in Bolivia, in France when due to lead poisoning, and in countries which have adopted the British formula and that of the Convention of 1925 (see also article "Infections").

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**Prof. J. Lowy.** (Prague).

**EYES**


**SOURCES OF INJURIES**

The causation of occupational injuries of the eye can be laid at the door either of environmental conditions, industrial processes or materials manipulated or liberated during work. Nevertheless, it is considered essential that the important part played by the constitution of the sufferer should not be ignored.

**Environmental conditions.** — First of all there must be taken into consideration atmospheric conditions, bad weather, sudden changes of temperature, humidity, and luminous radiations, the injurious effects of which are obvious in the case of such categories of workers as agricultural labourers, sailors, boatmen and drivers of vehicles.

Ordinary light, and especially direct sunlight, may be injurious under certain occupational conditions, as when, at high altitudes, through dazzle from snow and glaciers, it causes ophthalmia, or when the skin of the eyelids has become sensitive to the effect of luminous rays through the action of such products as pitch, tar or anthracene.
Sources of artificial light are especially injurious when they are rich in ultra-violet or infra-red rays (Vogt and his pupils); when their luminous intensity is insufficient or excessive; when the lights are inadequately placed or are too bright; or when the contrasts are too pronounced (see article "Industrial Lighting"). Similarly, it is necessary to take into consideration in many occupations the effect of heat rays, either isolated or associated with the preceding, and also of X-rays, radium and radio-active bodies.

Low temperature may likewise exercise an injurious effect on the eyes.

**Conditions of work.** — It is merely necessary to mention that excessive and prolonged work, especially when it is fine and the lighting is inadequate, is the cause of eyestrain and of several ocular affections. Even though such work does not usually cause definite anatomical lesions, it does in every case lead to functional disturbances — sometimes very severe — of accommodation, of refraction, and of the extrinsic muscles of the eye.

**Materials manipulated or liberated.** — This group represents the chief source of eye injuries.

From a practical point of view, materials manipulated or liberated may be said to injure the eye in solid, liquid or gaseous forms. But under any of these forms, the materials may exercise a mechanical, thermal, chemical or infectious effect, or more often a mixed effect.

In fact, the workman may be exposed to the effect of dust, liquids or fumes at a very high temperature, or to the effect of particles, especially metallic, at high temperatures, and at the same time to the effect of irritant or toxic gases.

First, there should be mentioned inorganic dusts from metals, glass, cements or stones, which are well known to be quite a common cause of ocular lesions: vegetable and animal dusts from flax, cotton, hemp, wood, tobacco, wool, animal or caterpillar hairs which act on the mucous membrane of the eye, either mechanically, or, more particularly, by chemical action through irritation, dehydration of the tissues, coagulation, or burning. The effect of dust obviously depends on the one hand on its composition (hardness, shape and surface of the particles, their solubility in the lachrymal secretion) and, on the other hand, on the quantity. But there are also materials which may cause a local toxic action or infection due to the microbes which they may contain, e.g. clothes and rags, and finally there is the very numerous group of dusts which exert a chemical action. The effect of all these dusts is aggravated by the habit of rubbing the eyes with dirty hands; a mechanical action which runs counter to its object.

**Chemical substances** may act on the eye by causing a temporary or serious lesion, quite independent sometimes of the duration of their action. No distinction can be made between the effect of these substances according to the form under which they act; either fumes, liquids or solid products may cause injuries of equal severity, according to their composition and the special conditions of action. Injuries to the eyes may be caused by phosphorus fumes, hydrocyanic acid, lachrymatory gas, phosgene, sulphuric acid, hydrogen, by nitrous fumes, by fumes of nitric acid, chlorine, acroleine or naphthalin. Droplets, liquids or solids may act by being projected on to the conjunctival mucus membrane, sometimes with very serious consequences; these comprise such substances as ethyl or denatured alcohol, the essential oils, benzene, its homologues and their nitro-amido derivatives; tar pitch, chemical manures, and basic slag. In the articles dealing with these different products full details are given of the eye lesions reported by experts.

Acids rank first in importance among the products which may cause burning or deep destruction of the tissues, next come the alkalids, and chief amongst these are lime and ammonia, the latter of which is perhaps the most dangerous of all bodies liable to attack the eye.

Disease of the eye may also occur as a symptom, isolated or not, associated with both general poisoning due to lead, mercury, arsenic, methyl alcohol, methyl bromide, sulphide of carbon, benzene derivatives or tobacco, and with such general conditions of the body as rheumatism or nutritional diseases. There may be also primary or secondary lesions of infectious or parasitic diseases, such as actinomycosis, an epizootic aphthous disease, ankylostomiasis, anthrax, glands, yphils, tetanus or palpebral vibrio gangrene. Among caisson workers and divers, tunefaction and emphysema of the eyelids and conjunctivae are sometimes observed, as well as changes in the fundus of the eye due to congestion of the optic disc, and paresis of the abductor muscle (Allan).

Some authorities have described eye affections among oyster-openers from
the dust generated, or from the projec-
tion of small splinters; lesions caused by
eel's blood owing to its haemolys-
ing action; and recently accidents of
severe nature due to scattering vaccina-
tion lymph.
Changes in the fundus oculi occur in
the case of serious burns on the body.
Thies has described two such cases,
which he attributed to toxins formed
on the surface of ulceraUons follow-
bring burns. In one well-known case,
that of a young chemist, blindness oc-
dered in one eye for twelve days and
in the other for nineteen days,
with, however, complete return to the
normal. Ocular lesions have been re-
ported following upon the effects of
pressure, such as work in compressed
air, of violent physical efforts with
detachment of, or haemorrhage into,
the retina of wounded and crushed
of the thrap, of contusions and serious
injuries of the body and especially of
fracture of the skull which are accom-
panied by changes in the eye giving
rise to haematoma in the lids, conjun-
tuUa, and optic nerve sheath.
Most of traumatic lesions — accidents —
to the eye must be given first place in
the occupational pathology of this
organ. Sudden violent lesions, caused
by flames, liquids or products at high
temperature, or products of which the
chemical action is serious, must be con-
sidered as industrial accidents from
the medico-legal point of view; as must
also all the numerous lesions caused
by foreign bodies, which too often lead
to perforation of the eyeball and to
loss of sight.
In certain occupations the eye is
much more exposed to accidents than
in others (see article "Metalisation ").
Metal workers are affected by metallic
splashes and particles of metal,
which are either in the molten state or at a
high temperature. Nevertheless in
the case of certain metals with a low
melting point, the particles may reach
the cornea almost cold, and cause less
severe injuries. Glassworkers are
exposed to burns from flames, gases,
liquids and hot solid bodies. Agri-
cultural workers are exposed to in-
juries from lightning, blows from
agricultural implements, and blows
from the tails or horns of animals,
which may produce rupture of the
sclerotic and subconjunctival disloca-
tion of the lens.
Foreign bodies may be superficial —
on the conjunctiva or cornea — or may
penetrate and be intraocular or intra-
orbital; in the first case the foreign
bodies may, however, be the starting
point of very serious secondary infec-
tious lesions.

STATISTICS

It is difficult to give statistics relating
to occupational diseases of the eye, as
most statistics deal chiefly with all forms
of oculo-trouble.
Eisenschön, of Prague, found that, of all
the lesions of the 'eyes treated in the
period 1907-1924 in his clinic, only 8.53 per
cent, were of occupational origin, of
which a third was accounted for by
corneal ulcer.
Fuchs, of Vienna, admits that eye-lesions
of occupational origin claim a percentage
of 8; but in order to reach this average he
included lesions with subsequent corneal
ulceration arising from chipping mil-
stones. According to this authority, a
third of the cases of loss of sight are due
to accidents.
The statistics from the Wolffen centre
(Bitterfeld, Germany) may also be quoted;
according to these, eye lesions of occupa-
tional origin in 1926 constituted 12.45 per
cent of all accidents, and in 1927, 11.16.
The German statistics show that it is on
the whole the occupations of stone-cutting
or metal working or work in the chemi-
 cal industry that show the greatest number
of eye accidents due to foreign bodies,
explosions and burns.
English statistics collected at the Home
Office Industrial Museum for the period
1924-1926 are also suggestive. They deal
with 20,459 cases of eye-lesions, about
7,000 a year, of which 8 were fatal. Their
distribution is as follows:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>1906</th>
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In the U.S.S.R., Meisl and Kybnik found
in 1925 among 2,484 workers at an electric
machinery works at Kharkow, 4,083 acci-
dents, 65% of which were injuries to the
eyes.
The importance of eye lesions of occupa-
tional origin is also clearly shown by
American statistics, which disclose the
fact that the ever-increasing use of pneu-
matic hammers and of compressed air
tools in general is a very frequent cause
of eye accidents. In the United States,
15,000 out of 100,000 eye accidents are of
occupational origin. The National Safety
Council estimates that about 200,000 eye
accidents occur each year, which means
that there is an eye accident every three
minutes, taking the year as 365 days and the working day as twenty-four hours.

In 1923, in Pennsylvania, 669 accidents resulted in the total loss of one or both eyes. Harry Best, in his inquiry into 90,242 cases of blindness, emphasises the fact that occupation is the most important cause of blindness.

During eight years the accident insurance companies of Pennsylvania paid 3,983,679 dollars for permanent incapacity from loss of limbs, upper or lower, as against 6,501,763 for permanent incapacity due to blindness. From 1918 to 1922 the railways of Pennsylvania, employing on an average 236,000 persons, found that 7.6 per cent. of all accidents were eye lesions, with a rate of 9.3 per 1,000 employed.

Some other Pennsylvanian figures, dealing with 691 eye accidents, indicate that 66 per cent. of all eyes lost belonged to coalminers or metal workers; 18 per cent. to 10 different industrial groups, 8 per cent. to those employed on constructional work and 8 per cent. to those employed in such public services as the post-office, telephone, telegraph or electricity.

The Travelers' Insurance Company found during three and a half years that among 1,049 cases of eye lesions, 424 occurred among mechanics, 102 among woodworkers, 76 among smelters, 61 among coalminers, 36 among chemical industry workers, 55 among stonecutters, and 55 among masons.

In the iron and steel industry out of 2,673 eye lesions found in 1923 in a single works, 17 per cent. of the accidents affected fitters, 14.4 per cent. smelters, 13.3 Bessemer furnace workers, 13.3 furnace workers, 12.8 tube makers, 12.5 electricians and 8 mechanics.

In 1922 in an American naval ship-yard (Philadelphia) there were reported 4,343 eye lesions, which had been caused by foreign bodies in 1,620 cases, by rust in 605 cases, by burns in 206 cases, by incrustation of particles in 552 cases and by splinters of steel in 79 cases. In 430 cases there was blepharoconjunctivitis, in 121 contact ulcers, in 162 electrical ophthalmia, in 61 contusions, in 28 chalazion, and in 3, cataract.

**PATHOLOGY**

For greater convenience attention will here be confined to examination of the different ocular lesions according to an anatomical plan, although of course subject to recognition of the fact that the morbid factors generally act on one or several parts of the eye, thus causing more or less complex syndromes.

**Eyelids. —** Pigmentation of the skin is quite common; it may go as far as atrophy with shrivelling in the case of persons working in the open air, such as sailors and agricultural workers. Pigmentation, especially in the form of simple erythema, is due either to luminous or heat rays, in the case of sailors, hunters, agricultural workers, mechanics or blacksmiths, or to chemical products, e.g. picric acid, tar or pitch. The pigmentation in time advances towards a reddish-brown and then to an intense brown. Small incrustations in the skin of the eyelids from small metal splinters are seen, and even small cicatricial points from burns among smelters and blacksmiths.

But it is chiefly the palpebral border which is affected, the irritation being due to dust, vapours, gases and fumes. The blepharitis is characterised by swelling and inflammation of the free border, with inflamed or glandular irritation and oedema. Blepharoconjunctivitis — blepharitis from dust — has been very well described by Le Roy des Barres and Courtois-Suffit, who distinguish the following kinds: simple redness of the palpebral border; an ulcerous form with small crusts on the level of the lashes or of the hair; small nodules of a furunculous kind; cicatricial blepharitis, due to the presence of small cicatrices caused by burns resulting from incandescent sparks, seen among blacksmiths and locksmiths; and obstinate blepharoconioses occurring among pit-saw workers; small turners, weighers of wheat, flax spinners, chemists, persons who crush medicinal barks, hemp spinners, brush makers, horsehair workers, feather dressers and furriers. The blepharitis leads to loss of the lashes, and the cicatrical healing of the lesions is often accompanied by ectropion or entropion.

A chronic eczema, which is tenacious, obstinate and difficult to cure, is caused by several products; it is aggravated by continual lachrymation, and especially by the act of wiping or removing the tears.

Aceneiform efflorescences, with the formation of warts and entropion, have been reported among tar workers.

Tumours are rare; nevertheless, Hessberg and Baer have described cancer of the eyelids caused by the irritating action of tar and pitch dust. Cases of rodent ulcers have been reported as sequelae to burns.

As regards infectious diseases, reference may be made to vibrio gangrene met with by Antonelli among agricultural workers in contact with manure; to the chance occurrence on the eyelids of malignant pustule, of glanders (not common), of botryomycosis, of syphilitic ulcer and the ophthalmomiasises.

In addition to various contusions and wounds, mention should also be made of burns of the eyelids, which may appear in three degrees: as simple
erythema, vescication, or necrosis of the tissues.

As regards the lachrymal apparatus, weeping constitutes — together with shutting the eye — the first line of defence of the eye against the irritative effect of foreign bodies, etc. Simple weeping generally disappears with the cause, but may become chronic in some cases, and give rise to various disorders of the lachrymal apparatus, such as narrowing of the canaliculi and dacryocystitis. Foreign bodies, such as caterpillar hairs, may cause rupture of the lachrymal sacs, with subsequent fistula and eczema of the commissure of the lachrymal sacs, with subsequent dacryocystitis. Foreign bodies, such as caterpillar hairs, may cause rupture of the lachrymal sacs, with subsequent fistula and eczema of the commissure of the eyelids, from constant lachrymation. Although very rarely, cases of actinomycosis of the lachrymal apparatus have been met with (Graefe, Forster). Purulent dacryocystitis is common among agricultural workers, who are frequently subject to cold, and show nasal affections of doubtful occupational origin, the dacryocystitis then being an ascending complication from the lesions of the nose. Among harvest reapers there is found a very high frequency of hypopion ulcer.

Changes due to streptothrix may be found in the lower lachrymal canaliculus, especially in women. It is very difficult to separate from the clinical point of view the lesions of the conjunctiva from those of the cornea, for they arise from the same causes and appear almost always at the same time.

The conjunctiva may show coloration and pigmentation from various products: yellow due to picric acid, violet to benzene, yellow to phosphorus, — and sepia brown — especially in the region of the palpebral opening — due to coal dust. Little black specks have been found on the conjunctiva at the level of the palpebral angle in post office workers, who apply sealing wax and hold it in a softened state in the flame of a candle for long periods. This smoke may cause extensive dermatitis, which is always accompanied by slight eye affections (Freund).

The commonest lesions are those which arise from acute, subacute or chronic irritation or inflammation of the conjunctiva, setting up conjunctivitis, characterised by redness, lachrymation, a feeling of grit or of small foreign bodies, photophobia, and a secretion which may be watery or purulent. Some forms of conjunctivitis are accompanied by small haemorrhagic effusions, as in cases of poisoning by arsenic, and irritation by sulphur dioxide.

Ophthalmia from electric light, following upon exposure to the electric arc, should be mentioned. According to the intensity of its effect, at the end of some hours of exposure to the light a more or less severe conjunctival hyperaemia is observed, with smarting, photophobia, blepharospasm and superficial lesions of the cornea. The cure may occur rapidly, but it sometimes happens, after between eight and fifteen days, that lesions of the deep membranes appear.

This kind of lesion has also been found in cinema artists (see article "Artists").

Workmen who make X-ray tubes are exposed to the effect of X-rays and may show lesions of the eyelids, conjunctivae and even of the lens. Almost similar lesions, but generally more benign, are found in the ophthalmias named after the snow or glaciers, by exposure to which they are caused. Chronic conjunctivitis, due in particular to the constant effect of dust and fumes, is characterised by certain peculiarities. Thus, for example, flour dust, which affects bakers and flour millers, becomes mixed with the lachrymal secretion and causes a diminution in the diameter or a definite blocking either of the lachrymal ducts, accompanied by an overflow of tears and chronic lachrymation, or of the excretory canals of the Meibomian glands, when styes and small abscesses on the palpebral border may result. In the case of men who cut hairs off skins and in the case of elderly hat makers, Haas and Helm have, on the other hand, found a diminution in the lachrymal flow consequent upon a reduction in the diameter of the lachrymal gland openings.

Workers exposed to all weathers may suffer from a thickening of the conjunctiva on a level with the palpebral opening. Tobacco sometimes causes the formation of small vesicles on the conjunctiva.

Pterygium has been observed frequently among masons, lime burners, plasterers, stonecutters, ceiling plasterers and farm labourers.

Cases of serious ophthalmomiasis have been reported among workers in tropical climates. In rare cases anthrax infects the conjunctiva and also glanderers, syphilis and actinomycosis. A case of botryomycosis has been reported by Bargeton. A case of severe conjunctivitis from the projection of vaccine into the conjunctival sac has also been recorded. Cases of trachoma are more common. In countries where this disease is endemic its transmission by means of tools among workmen has been reported. Epizootic aphthous dis-
ease is characterised by vesicles on the conjunctiva.

As a rule conjunctival lesions do not occur alone, but are accompanied by lesions of the cornea in the form of kerato-conjunctivitis.

In the case of wood turners a certain degree of loss of corneal sensibility has been observed; this is dangerous in that workers only notice lesions due to foreign bodies when there is suppuration (Sanovjoloff). Diminution or complete loss of sensation in the conjunctiva and cornea has also been noticed in poisoning by carbon bisulphide, as the first eye symptom in addition to general disorders of sensation (Oblath).

The cornea may also present various discolorations, black due to tar, or yellowish-brown due to aniline dyes, especially at the level of the palpebral opening.

Irritating substances acting on the cornea, may give rise to interstitial opacities (corneal opacities) which have different appearances according to the cause — dull or like porcelain when caused by lime, or thick and non-translucent when caused by superphosphates. These opacities are often accompanied by a tendency to the formation of small vesicles with desquamation, when due for instance to lachrymatory gas or aniline, and always by agonising pains. The changes caused by lime leave a white, indelible scar; those due to aniline have been actually observed by Vogt during experiments on rabbits, which died following severe eye complications.

Small wounds and foreign bodies sometimes cause slight losses of tissue which cicatrize rapidly. Sometimes they lead to the formation of corneal herpes, which may finally result in opacity of the cornea. Herpetic virus is often the cause of keratitis in the form of Fuchs's disc. A deep keratitis has been found in stable boys (very similar to that of Fuchs), which is perhaps the result of superficial injuries due to penetration by very small foreign bodies of vegetable origin.

The cornea of stone workers has a characteristic appearance; it is scattered over with very small foreign bodies consisting of stone particles, which have penetrated the Substantia propria under Bowman's membrane, but which do not cause discomfort to the men. The cornea of these workers likewise shows numerous and very small punctiform or linear opacities, which are the result of very slight injuries, often not felt by the workmen themselves.

Among persons who gather chestnuts there are frequently noted on examining the eyes fine prickles which come from the spinous envelope of the chestnuts. These fine prickles, armed with barbs, on reaching the corneal tissue, set up there a definite irritation; their extraction is not easy (Oblath). As sequelae to these lesions small opacities of the cornea are found.

Wounds by aniline pencils, especially methyl violet, may range from a slight graze and coloration of the conjunctiva to more or less severe affections of the cornea. As sequelae to these lesions small opacities of the cornea are found.

Forms of keratitis are very common in a number of industries, such as dyeing, soap making, sugar refining, and weaving; for example, in the weaving of artificial silk, Krahnstover, after examining a large number of workers with the slit lamp, reported a characteristic superficial inflammation of the cornea, which had the appearance of being spotted with little vesicles.

These lesions have been the subject of numerous researches in several countries (Rodenacker, Colrat, Loriga, Kranenburg, etc.) where experts have often attributed them to the effect of sulphured hydrogen (see article "Artificial Silk"). Superficial corneal changes and conjunctivitis, found among workers at refineries for sugar beet, have also been attributed to this gas (Rochat).

Corneal ulcers are serious lesions, sometimes due to secondary infection complicating lesions caused by inflammation of foreign bodies in the cornea. Among the ulcerations caused by the direct action of chemical products should be mentioned corneal ulcer caused by lime, which may heal, but with the formation of extensive leucomas which are frequently vascular. Granulation tissue, deformity of the eyelids and symblepharon result from the burning action affecting the conjunctiva, and particularly the cul-de-sac. In the most serious cases the cornea and conjunctiva are always affected. The lesion may also produce necrosis with perforation of the eyeball. Thus it is seen that even non-penetrating wounds of the eye may sometimes lead to its loss.

Chemical burns of the cornea may, like burns, be of different degrees of severity, depending on the factors which have caused them: the quantity of the caustic substance, the period of action, the pressure and force with which it has penetrated, the intensity
OCCUPATIONAL DISEASES

of the caustic strength, and its chemical nature. In the case of burns of the skin of the eyelids belonging to the first degree in severity, the inflammation of the conjunctiva rapidly disappears. In the second degree, vesicles and phlyctenules form upon the eyelids, with vitrifaction of the cornea which may even take on a clear whitish-grey coloration, if due to alkalies. Acids precipitate albumins and produce a hard crust; alkalies liquefy the albumins and form alkaline albuminates with soft crusts. Hydrochloric acid causes similar lesions to those caused by ammonia. It also causes opacities of the lens (Fehr). Lime exercises a caustic action, and, in addition, unites with the tissues to form incrustations and impregnations leading to opalescence and a milky appearance of the cornea.

The third degree is characterised by superficial necrosis of the skin, conjunctiva and cornea, with opacity and intense cloudiness. Ammonia is the most dangerous of all caustics. A serious caustic burn by ammonia, according to the description of Abadie, makes an eye look like the eye of a cooked fish. After some days, the eye recovers its normal appearance; but about the eighth or tenth day a sloughing of the membranes of the eye follows, despite every care. The danger arises from the great affinity for water possessed by ammonia, and from the fact that ammonia often enters the eye with force and pressure, for example while repairing refrigerating machines. Even a 10 per cent. solution of ammonia is dangerous, and eye accidents are reported to have led to the loss of the eye, when, during efforts to revive persons who have fainted, smelling salts have been poured into their eyes. Here also, a week after the injury, there superimposed increase in the intraocular pressure (glaucoma) and opacity of the lens.

The degree of heat, the nature and duration of the action of the injurious agent affect the seriousness of burns: redness of the skin, scorching of the lashes and eyebrows, with a sensation of heaviness in the eyes, characterise the first degree; lesions of the conjunctiva, especially the corneal part, with oedematous swelling and the formation of small white superficial scales characterise the second degree; while profound changes in the skin of the eyelids and of the subcutaneous tissue, the healing of which is accompanied by troublesome scars leading to deformities, together with necrotic processes on the cornea, formation of granulation tissue which causes union between the lids, characterise the third degree.

It must not be forgotten that in some cases tears play an important protective part.

Lesions caused by vaccination lymph are characterised by rapid corneal infiltration, with iritis, ulceration of the cornea and irido-cyclitis, terminating with enucleation of the eye (Debord and Villard).

The iris is often involved in the case of lesions of the cornea, and reacts by sero-purulent exudative inflammatory processes. In corneal ulcers, perforation with protrusion of the iris is frequently found, with anterior synechiae and secondary glaucoma, which causes cupping of the optic disc. Secondary glaucoma can also be caused by such inflammatory processes of the iris (iritis with hypertension and posterior synechiae, etc.). Mention must also be made of iritis and nodules of the iris caused by caterpillar hairs, as well as the iritis due to aniline fumes, to podophyllin and to cantharides (Oblath).

Cases of iritis have been recently reported as occurring amongst photographers exposed to the action of ultra-violet rays (Duke Elder).

The lens presents, particularly as occupational lesions, opacities and cataracts, of which the best known is that of glassmakers; it occurs, however, among persons employed in other occupations than glass making for instance among workers employed at blast furnaces, blacksmiths, smelters and solderers. A case of cataract in a doctor who worked constantly with X-rays and radium has even been recorded (Elschnig).

Occupational cataract, that is to say, that of glass makers and workers exposed for long periods to the effect of metals in an incandescent or melted state, starts by a small opacity situated at the posterior pole of the lens. This opacity progresses subsequently very slowly. Sometimes a dehiscence of the zonular lamella on the anterior surface of the lens is noticed, a lesion to which Elschnig attaches great importance for differential diagnosis from non-occupational cataracts. The left eye, which is generally more exposed to the injurious effect, is affected before the right, which, on the contrary, is the more exposed among mechanics. As regards the pathogenesis of occupational cataract, direct action of luminous and heat rays on the lens fibres must be acknowledged, as well as the indirect effect from heat on the ciliary body and iris; whence follow changes in the nutrition of the lens.
Cataract is found in about 17 per cent. of workers exposed to the effect of incandescent masses of metal after not less than ten to twenty years from commencing their occupation. It is quite easy to differentiate the start of occupational cataract in its early stages from congenital or senile cataract. On the other hand, differentiation between fully developed occupational cataract and senile cataract is difficult.

In addition to lesions of the lens, with partial or total cloudiness which may be stationary or progressive, and may appear more or less rapidly after exposure to the injurious rays of the electric arc, cataracts caused by lightning, a somewhat rare form of electric cataract, which is unilateral and congenital, is composed of epithelial cells, at the point where the current has its entrance and exit.

Electric cataract hardly ever appears immediately after the lightning stroke, but more often several weeks later. It probably arises from a lesion of the subcapsular epithelial cells, due to the lightning, whence originates opacity of the lens. This opacity is not situated on the layer of the epithelial cells.

In siderosis of the eyeball, caused by particles of oxide of iron, which spread in the eye by the lymphatic channels, a red coloration of the iris is seen, and a cloudiness of the lens, the surface of which is speckled with yellow spots; cloudiness is also present in the vitreous body with changes in the retina and notably in the yellow spot. The iron particles appear, if they are very recent, as little brown specks; if they are not extracted and remain in the tissues, they appear as little specks of a rusty colour. In the long run they may cause serious injury. Siderosis of the cornea and of the iris, i.e. siderosis of the eye, causes after some months subcapsular changes and, finally, posterior changes in the lens and after a more or less prolonged period, blindness from retinal lesions.

In the case of foreign bodies composed of copper (chalcosis), a greenish-blue coloration of the iris is found, and an opacity of the lens in the form of a whirligig or a wheel, forming the pseudo-cataract of Purtscher. Copper is deposited in particular near the limbus, from which comes the annular form of corneal opacity caused by copper.

Mention should also be made of cataract caused by trematodes (Oblath).

Lesions of the deep membranes of the eye may be due to the action either of toxic products, or of radiations from light, heat or electricity, or of foreign bodies, or even of fatigue of the eye.

The chief symptoms are diminution in visual acuity, asthenopia, hemeralopia, hemianopsia, amblyopia, amaurosis, colour blindness, sometimes coloured vision, for example, red among workers at blast furnaces and foundries, and yellow in cases of arsenical poisoning; reduction of the visual field; scotoma for colours, especially for red and green, due to bisulphide of carbon, and various forms of annular scotomata and central or peripheral scotomata due to light.

Medical examination may disclose the existence of chorioretinal irritation; stasis in the Fundus oculi, with engorgement of the retinal vessels; papillary hyperaemia due to tobacco or carbon monoxide; ischaemia of the optic nerve, with mango-like retinal arteries caused by methyl alcohol. Retinal haemorrhages have sometimes been reported; but the chief injuries are generally from retrobulbar neuritis and neuro-retinitis with changes round the papilla, due to alcohols, carbon bisulphide or lead.

Litten has observed an intense violet coloration of the fundus oculi and optic nerve during poisoning by benzene, with a peculiar appearance of the arteries and veins which were coloured black.

The eye muscles, both intrinsic and extrinsic, may be affected by disorders of occupational origin. Among the extrinsic muscles the external rectus is sometimes paralysed in poisoning by lead, tobacco or carbon monoxide. This gas has also caused ophthalmoplegia with marked exophthalmos. Nystagmus is a very important neuritis, which is the subject of a special article.

The intrinsic muscles may also be affected, for example, during poisoning by carbon monoxide, lighting gas or benzene, with paralysis of the iris muscle. Alteration in the pupil reflex with inequality of the pupil may arise from carbon monoxide, aniline or arsenic.

The ciliary muscles, if fatigued, cause accommodation asthenopia among printers, engravers and watch-makers. They may become paralysed during lead poisoning, poisoning by bisulphide of carbon or benzene.

The myopia which is found in some occupations, as well as eye strain, may be associated with defective accommodation. But, although writers in the past have attached much importance to occupational myopia, the aetiological importance of close work
is nowadays very much doubted. The careful examination of statistics indicates, as a matter of fact, that it is not the occupations which create myopes, but that the myopes themselves have adopted such and such an occupation in consequence of their infirmity (Berhof-Harman).

HYGIENE

The prophylactic measures to be adopted for occupational diseases of the eye comprise general and special hygienic measures. Among the first should be mentioned general measures of hygiene for workplaces, and especially those which are aimed at lessening or suppressing such causes of injury as dust, vapours, gases and fumes, or those which deal with lighting, natural or artificial (see article "Industrial Lighting").

As regards the prophylaxis of occupational cataract, spectacles or special lenses proposed by Crookes and by Vogt may be worn, but they have not been favourably received by workmen. Good ventilation must be provided in front of the openings of furnaces. Above all, automatic and semi-automatic systems of work should be provided which do not expose workmen to injuries from heat, intense radiation, physical exhaustion and eye-strain. The progress of industrial technique may soon result in the disappearance of glass-makers' cataract.

Special measures have led to the protection of the eyes either by means of screens against too bright a light, or by means of breathing apparatus and goggles (see articles under these headings). In Germany some chemical firms have made compulsory, under penalty of a fine, the wearing of protective goggles, and this immediately reduced the number of eye accidents. A similar regulation was laid down by the Italian Government in its Industrial Hygiene Code.

Prophylaxis for eye lesions during manipulation of poisonous products is the same as that for the poisons themselves. Hence arises the necessity for personal cleanliness and for medical examination, either on joining or periodically during work, in order to eliminate persons predisposed to eye lesions, or to detect the first signs of poisoning.

LEGISLATION

Eye lesions which can be regarded as symptoms of an occupational poisoning, either by lead, mercury, benzene or carbon bisulphide, are as a general rule compensated according to legislative provisions which may include a list of occupational diseases. However, in some countries the legislature has extended the compensation to other eye lesions, for example, lesions of the skin and eyelids by caustic liquids, dust or certain products such as tar or pitch (see article "Skin Diseases"). Other diseases of the eye included in notification or compensation lists are the following: conjunctivitis is compulsorily notifiable in the Netherlands in the case of persons employed in briquette works, autogenous welding, sugar refineries, gas works, artificial silk works, and in the transport of pitch or products containing this substance. In Japan, diseases which are caused by substances at high temperature, by irritating gases or dust are compensated.

Ulcers of the cornea and conjunctiva are compensated in Great Britain and in the States of Minnesota and New York when due to paraffin, pitch, tar, bitumen and mineral oils; in Ohio and Porto Rico when due to carbon, pitch, tar or tar compounds; in Western Australia and Queensland when due to mineral oils, pitch, tar and tar compounds; in Venezuela, corneal ulcer from tar, pitch, mineral oil, petrol, paraffin and tar derivatives is compensated. In the Netherlands ulcers are compulsorily notifiable when they occur in the following occupations: agriculture; briquette-making; phototyping; refining; distillation of crude petrol, tar or pitch; incandescent mantle works; work on mas- onry, asphalt and coal; autogenous welding and cutting; the manufacture of incandescent lamps; dyeing of textiles; stone-cutting; forges and enamel works.

Cataract is compensated in Germany when affecting glass workers, smelters of iron and metals; in Great Britain when affecting glass workers, and smelters of iron and steel; in Austria glass workers; in Russia in the case of the continued effect of radiations of great intensity among glass blowers and workers in the metallurgical industry; in Chile and Venezuela in the case of glass workers; and also in Minnesota and New York State in the case of glass workers. It is compulsorily notifiable in the Netherlands for glass workers, steel workers and foundrymen. For nystagmus, see that article.

Retinitis and optic neuritis are compulsorily notifiable in the Netherlands (when occurring amongst workers engaged in coke furnaces, gas works, phototyping and autogenous welding), and in Poland; in Russia there is compensation as for cataract.

BIBLIOGRAPHY


 Ear, Nose and Throat

It may be premised that occupational diseases of the ear, nose and throat do not often lead to incapacity for work, nor is a fatal issue of common occurrence. Diseases of these parts do not therefore figure largely — indeed, may be said scarcely to figure at all — in the lists of compensation cases in the law courts. A boilermaker is almost certain to become deaf in the course of his work, but he does not seem to become less efficient as a workman on that account, nor is his longevity prejudiced. A chrome worker is very liable to develop a perforation of the nasal septum, but is seldom laid aside from his work even during the stage of acute ulceration, and after healing has taken place he is not apparently any the worse. In cases where a fatal issue or incapacity occurs, as may happen in lead poisoning and compressed-air illness, although symptoms referable to the internal ear may be present and even prominent, the incapacity or death is always due to disturbances of the general system.

I. — DISEASES OF THE EAR

Occupations which expose the various parts of the ear to injury of an occupational character are numerous, and the etiological factors, which are constantly increasing as authorities devote increasing attention to their detection, are very numerous.

Sources of Injury

Amongst the sources of injury the foremost are noise and vibration (see article “Noises”). As regards detonations and explosions, it must be stated that in the case of these (accidents, probably so-called, rather than occupational diseases) the organ of hearing is more often injured than is at present recognised. Where symptoms other than those of the ear predominate, this is to be attributed to the fact that the latter are late in being detected, sometimes only after the lapse of several years. The lesions are due to several factors: intensity of speed in pressure changes (where the explosion is produced in enclosed places, secondary shocks add to the force of the main explosive shock); calorific action of the flames from the explosion; atmospheric pressure: at times there is a general superpressure (caisson workers, divers) or merely at the level of the middle ear (glass blowing with the blowpipe); sometimes decreased or increased variation of pressure due to altitude or atmospheric depression — in the case of accelerated movement (aeronautics, aeroplanes, railway travelling); high temperature and radiant heat (metalurgical industry, chemical industry, potteries, mines, glass factories); hot and humid atmosphere (textiles, breweries); rapid changes of temperature, draughts (transport industry, gamekeepers, fishermen, agricultural workers, workers in the building trade, postmen, masons, laundry workers, cooks, etc.).

Very important sources of injury are constituted by dusts (solubility in organic liquids, size and shape of the particles, etc.), liquids, gases and fumes, the action of which depends on their quantity and chemical constitution.

A number of toxic products cause injury to the ear, either by exterior local action, or more often by a general internal action: hydro-carbides of the aromatic series, arseniuretted hydrogen, mercury, nicotine, carbon-monoxide, lead, carbon-di-sulphide, etc. (Voss). Various infective agencies may also become localised in the organ of hearing. Besides violent traumatic shocks, which may cause particularly lesions of the bony part of the ear, Voss recalls the harmful influence of slight and repeated traumatism (headpieces worn by telephonists), foreign bodies (ears of corn, splinters of wood in the case of agricultural workers) electricity, etc.

Statistics

While there is absolutely no doubt that ear disease is current amongst workers in certain occupations, it is nevertheless true that good morbidity statistics for these diseases are lacking (Peyser). In fact examinations carried out in the workshop are often superficial or incom-
complete; the data taken from figures provided by sickness funds and occupational organizations are notoriously inadequate, at least as regards initial forms; it should be added that a great majority of these lesions are mostly overlooked by those who suffer from them, by reason of the fact that they become accustomed to the action of the harmful agencies and to the rather slow progress of the lesions in question (Glogau).

According to Peyser, the University Ear Clinics only recorded, in 1913, 13 cases of deafness of occupational origin, amongst 2,500 admissions to the Breslau Clinic (0.52 per cent.); 80 out of 9,360 at the Berlin Clinic (0.95 per cent.); 37 amongst 1,973 patients (1.9 per cent.) in Roepke’s Clinic at Solingen.

Glogau reports that amongst 60 tobacco workers under his care there occurred 7 cases of ear disease, 70 cases of nasal trouble, 153 cases of disease of the pharynx, 12 cases in which the larynx was affected. Amongst 155 workers in ostrich feather and fur factories and in rope works, the same authority treated 337 cases of nasal trouble, 142 cases of disease of the pharynx, 131 of the middle ear, 49 of the internal ear, and 17 of the larynx.

Amongst 470 patients examined in 18 different factories, Peyser found 256 cases (53.5 per cent.) of ear disease.

The data relative to occupational deafness are more numerous. The facts are dealt with in detail in the articles “Copper Boiler Making” and “Transport Workers” (Railway Workers). It is sufficient therefore to recall that Wiehe (quoted by Voss, 1914) found amongst 65 locomotive mechanics 3 cases of acute otitis, 10 of chronic otitis, 12 of sclerosis and 5 of suppurrative otitis.

The statistics of the Leipzig Fund (1912) show that ear diseases amounted to a case rate of 19.5 per 10,000 members, with an average duration of 20.6 days; whilst the same rate for members belonging to the railway staff (locomotives) was 35 per 10,000 members, with a duration of incapacity averaging 37 days. This category of workers is, according to Boval, subject to affections of the middle ear rather than of the internal ear, many individuals showing predisposition to deafness as a result of a defective state of the upper respiratory passages.

In regard to other occupatations, Gottstein and Kaiser found good hearing in the case of 29 of the 75 blacksmiths examined, fairly bad in the case of 16 and bad in the case of 36. Holt found only 6 bottle-makers out of 40 examined who had good hearing, Barr only 9 out of 100 who had an average duration of employment of 17 years. Habermann found only 1 out of 31. Blevgad found marked diminution of hearing affecting 75 out of 354 telephone employees examined.

Lesions connected with deafness are proportional to the length of employment in the dangerous trade. Thus, e.g., according to Zwaardemaker (quoted by Castex), 25 per cent. of a number of workers suffering from deafness had worked 1 to 5 years; 35 per cent. 6 to 10 years; 50 per cent. 10 to 15; 60 per cent. 16 to 20 and 90 per cent. 20 to 25.

Similarly, Boval found that the incidence of deafness amongst engine drivers increased with age (from 11.7 to 62 per cent.) and with length of service (from 18 to 25 per cent.). In order to verify the current belief that weavers suffer from deafness, the English Inspectorate in 1927 subjected to thorough examination 1,011 cotton weavers (Dr. Henry) who had worked from periods of 1 to 64 years: 246 workers (24.3 per cent.) showed a certain degree of deafness and were sent to a specialist for opinion. The latter reported that deafness was due in 30.4 of the 246 cases examined to chronic suppurative middle otitis; in 27.4 per cent. to a nerve lesion; in 19.5 per cent. to wax; in 17 per cent. to catarrh; in 11 per cent. to a traumatic form. In the case of 0.6 per cent., there was found chronic catarrh of the middle ear with nervous deafness and acute suppurrative otitis of the middle ear.

**PATHOLOGY**

Injuries may affect separately the external, middle, or internal ear, but more often they affect several parts of the ear simultaneously.

(1) **External Ear**

**Pigmentation of the auricle,** by the simple deposit or penetration into the skin (tattooing) of particles of matter manipulated, occurs fairly frequently with colouring, varying in accordance with the products in question: black (coal, iron); grey (emery); bluish (silver); blue (aniline). (See article “Skin Diseases”, Stigmata.) Hypersensibility of the skin of the auricle has been found amongst telephone workers as a result of the constant pressure of the headpieces (Röpke, Blevgad), amongst sisters of charity, due to the wearing of a head-dress (Voss).

**Chilblains** are of frequent occurrence amongst workers in the open or in unheated workrooms (food industry or cooling chambers), or amongst workers subjected to sudden changes of temperature. There has, at times, been noted inflammation of the auricle and perichondritis with thickening and even subcutaneous sero-sanguineous discharge followed in some cases by escharification and necrosis.

**Burns** are equally frequent and may be due to direct contact (molten metals) or to radiant heat (metallurgical workers, glass workers, machine stokers, etc.). It is generally a case of superficial lesions, but at times of burns involving permanent deformity.
Traumatisms play a fairly important role: varied wounds, parochondritis, hematoma (professional sportsmen) (Southan, Ochsen, Körner); wrestlers, acrobats (Bloch, Zanfal, Valentin). Zakaki has reported 29 cases of deformation of the ear due to hematoma amongst 72 Japanese boxers. Amongst transport workers carrying loads on their shoulders such lesions may at times involve atrophy of the auricle (Laubinger-Lehr, Körner, Muller, Kronenberg). Even amongst doctors there have been reported cases of hematoma due to friction of the stethoscope (Ligin).

Amongst accidents there may also be recalled the kicks and bites of animals, explosions, detonations, etc.

A more important place is occupied by forms of dermatosis due to dusts, liquid irritants, irradiant gases, development of which is so often favoured by perspiration and which are frequently aggravated by rubbing, scratching and lack of cleanliness. The most varied cutaneous forms are met with, ranging from simple irritation with erythema, inflammation, eczema, boils, to ulceration. There have also been reported cases of epitheliotma of the auricle due to tar.

At the level of the external auditory meatus there may be noted lesions due to the presence of foreign bodies: metals (blacksmiths); stones (masons); wood (woodcutters); straw, grain (harvest workers); splinters of wood (gamekeepers and hunters); dusts generally involve lesions which vary according to the nature of the dust: ranging from simple obstruction (iron, steel, coal, flour) up to an irritant action (zinc, lead and arsenic ore, or ore containing chrome or cadmium) with diffuse dermatities or eczemas, or even ulceration of the external auditory meatus.

Auto-mycoses are fairly frequent. Siebermann found in examining agricultural workers and carters cases of this to an extent of 29 per cent.

Mycosis of the external auditory meatus (*Aspergillus niger, flavus or *fumigatus*) occurs amongst agricultural workers, weavers, spinners, woolleners, paper-mill tenders and laundry workers. They work in atmospheres and fatty soil favour growth of the spores. Repeated attacks may cause thickening of the dermal coat of the tympanic membrane and so lead to impairment of hearing.

Besides *Aspergillus* and *Penicillium*, harvesters or threshers of corn are exposed to the action of *Ustilago carbo* and *Tilletia Levis* and *Actinomycosis* (Urbantschitsch). Grazzi has met with a case of auto-mycosis due to *Ustilago carbo* affecting a naturalist, and Braustein and Blevgad cases of automycosis amongst telephonists.

(2) Middle Ear

There have been reported cases of redness, congestion, oedema or atrophy of the drum amongst workers in the transport industry, aviators, aeronautical workers, fishermen, sailors (action of air-movement), glass workers and workers in the chemical industry.

Cases of ecchymoses have been noted amongst caisson workers, sponge divers and other divers. Penetration of particles of material manipulated (metal particles, pieces of straw, splinters of wood, etc.) may cause more serious lesions. Ordinary burns and chemical burns due to penetration of molten metal or boiling or corrosive liquids and even, at times, of gases have been recorded by several authorities.

Rupture of the *membrana tympani* may occur from explosions in mining or blasting operations or in gun firing or shell bursting, or among divers and sponge fishers. As a rule speedy repair takes place unless suppuration of the middle ear occurs from infection.

Injured, atrophied or scarred drums are particularly pre-disposed. Shrinkage of the external auditory meatus likewise favours rupture. The drum may also show modifications of its natural convexity towards the interior part of the tympanum due to hyper- or hypo-pressure in the middle ear (aviators, glass-blowers, telephonists, etc.). Such troubles are often accompanied by temporary deafness, nausea, vertigo, etc.

Shrinkage of the drum due to spasm or contraction of the muscles of the middle ear (tensor muscle, stapes muscle and malleus muscle) has been encountered by Blevgad, Peyser, etc., amongst telephonists on the side at which the listening apparatus is applied (Hansen, Borkendahe, Pollack, Urbantschitsch), amongst boiler-makers, blacksmiths, mechanics, engine-drivers, etc. It must, however, be admitted that the question of occupational disease as affecting the muscles of the middle ear is one which calls for further and more detailed research.

Lesions of the middle ear by way of the external auditory meatus and the ear drum are very rare. However, perforation of the drum (not of occupational origin) exposes the victim to middle otites, by penetration of water
(professional bath attendants and divers) and toxic products (nitro-amido derivatives; Kurschmann), but the most important occupational disturbances originate in the mucous membrane of the nose and the pharynx by way of the Eustachian tube. It is in this manner that in the case of workers who are subject to nasal catarrh in the Eustachian tube and to nasal pharyngitis (aviators, orators, divers, workers in the dusty trades, etc.), forms of middle otitis constitute a fairly frequent complication.

Forms of acute catarrhal otitis due to cold, though relatively rare, occur amongst workers in the open air (Opitz, Peyser) and more often amongst workers exposed to sudden changes of temperature. These forms of otitis occur in combination with those due to other causes; dusts, irritating fumes, etc.

Kerr Love has drawn attention to the presence of coal dust in the middle ear of coal-miners. These forms of otitis are chiefly caused by the irritant or infectious effects produced by dust on the mucous membrane of the nose and naso-pharynx.

(3) Internal Ear

By far the most common occupational disease of the ear is nerve deafness induced by exposure to loud sounds (see article "Noise").

These may be manifested by transitory crises (aviators and mechanics engaged in motor testing); neurotic deafness due to the noise of the motor either during flight or in the hangar (Ranken), which likewise constitute initial symptoms of permanent and progressive deafness. This form, which is most frequent amongst boilermakers, is only met with in general after a more or less extensive period of work, (three to five years on an average). At the outset the symptoms of deafness may be attenuated by rest, especially by the Sunday rest, but gradually the lesion becomes more and more deep-seated, reaching a maximum after the lapse of fifteen to thirty years.

An interruption of work lasting eight days brings about no improvement in this deafness. A longer absence (several months) on the other hand may retard the onset of deafness (Holtzmann).

Sometimes deafness sets in more rapidly; development only lasting a few months. However, under ordinary conditions and equal length of employment certain workers are affected, while others remain immune. Early and serious deafness is met with amongst subjects manifesting defects of the Eustachian tube, or more particularly chronic lesions of the rhinopharynx, accompanied by the symptomatic complex of adenopathy.

Occupational deafness once established is characterised by a more or less marked diminution of hearing affecting both ears, or oftener only the ear usually most exposed to noise. Defective perception is confined at first to predominant sounds by which the workers are exposed. For a long time diminished hearing is restricted to high-pitched sounds corresponding to such noises, and it is only ultimately that there is noted diminution of hearing for other sounds.

The clinical data relative to boilermakers' deafness has been adduced in detail by Ritchie Rodger in the case of 50 boilermakers representative of all ages and all lengths of service. A first series of researches dealt with the approximate alternation of the pitch of sounds predominating in boiler shops, varying between 400 and 500 double vibrations per second. Workers were examined with the aid of tuning forks: 1 of 32 double vibrations to test the perception of low notes; 2 forks of 419 and 512 double vibrations, corresponding to the lower and upper limits of the predominant noises; 1 tuning fork of 2,048 double vibrations for testing the hearing of high notes, and a monochord was used to determine the upper tone limit. It was found that all workers in noisy trades, even after some weeks of employment, present some degree of deafness. Amongst the youngest workers the troubles only affected hearing as determined by tuning forks, corresponding to the noises in the workshop. According to Ritchie Rodger, loss of hearing of high-pitched sounds is not characteristic of deafness amongst boilermakers, as has up to the present been affirmed. The first authors to write on the subject (Barr, Hubermann) had to do with workers who did not apply to them except when seriously inconvenienced by deafness. The workers examined by Ritchie Rodger had not reached this stage, and the majority of the young workers vigorously denied being affected with deafness. This authority noted besides that all the workers examined showed loss of perception for tuning forks, corresponding to predominant sounds, indicating atrophied atroophic stretch of cochlea corresponding to that pitch without depreciation above or below. A young worker could even
hear 20,000 double vibrations per second on the monochord and showed normal acuity for 32 and 2,048 per second, whilst his appreciation for tuning forks 419 and 512 was reduced to two-thirds. Amongst men who had been exposed to noise for a longer period, the principal characteristic noted was a diminution of hearing for the highest notes as in the case of all forms of nerve deafness. Hubermann, in his researches effected amongst boiler-makers, came to conclusions which are, on the whole, similar.

The degree of seriousness of the lesions is proportional to the length and intensity of the sounds and noises of varying pitches, and they are generally found in the upper parts of the first spiral and at the commencement of the second (Ritchie Rodger, Van Eicken, Grünberg, Yoshii, Hössli, Hubermann). According to experimental research engaged in by Holtzmann and Maue, the most serious changes take effect in the ganglionic cells whilst the nerve and the organ of Corti are not attacked.

However, where the damaging agent exercises its effect over a long period these authorities have met with serious lesions of Corti's organ, but they have never noted definite lesions of the nerve. The vestibular apparatus is generally said to remain unaffected (Wittmaack, Siebenmann, Yoshii) and it does not begin to be affected until the animals are subjected to vibrations or violent detonations (lesion of the semicircular canals). Other recent observations would appear to prove that the presence of vibrations is not essential in order that noise should cause injury to the ear.

Discussion has for long centred round the problem as to whether injury to the internal ear is air-conducted or due to vibration. All observations made concur in showing that the principal mode of attack of the internal ear is by way of the transmission mechanism of the middle ear. However, the question of indirect implication of the sound-transmitting apparatus as well as that of the existence of changes which, if they be due to noise, do not progressively diminish the conductivity of the principal means of transmission of sound waves to the internal ear, is still sub judice. The clinical observations of Hensen, Bockendall, Pollack and Urbantschitsch show that contraction of the tensor muscle of the ear-drum and the consequent fixation of the apparatus for transmitting sounds, to which is added thickening of the tympanic membrane, constitute amongst workers in the noisy trades
OCCUPATIONAL DISEASES

an obstacle to the transmission of high-pitched sounds.

Pre-existing diseases of the middle ear are said to constitute, according to certain authorities, protection against nerve deafness. These diseases, the most common of which is perforation of the ear-drum, with or without otorrhoea, are said to lead to less forcible impact of the stapes against the oval window, and so to lesser injury of the cochlea. Perforation of the ear-drum is said to be without effect on the outbreak of occupational deafness (Holzmann). Certain authorities hold that this damping effect occurs also in cases of adhesions in the middle ear. In any case the removal of the incus or the induction of middle-ear suppuration in animals obviates the onset of cochlear changes (Van Eicken and Hössl). This favourable influence of middle ear suppuration, noted also by Ritchie Rodger, has not been confirmed by certain authorities who, on the contrary, consider that such conditions exert an influence causing pre-disposition to internal-ear lesions (Gradenigo) is of the opinion that catarrhal lesions of the middle ear play an important role, notably in altering the motility of the incus and malleus muscles, which are considered as the muscles of defence of the labyrinth passage.

Deafness is often accompanied by subjective noises, singing and whistling in the ears and a certain amount of hypersensibility to noise which may be interpreted as phenomena of cochlear irritation, and at times by perversion of the sense of hearing (Layet), with reduced hearing for high-pitched sounds and a sadden loss of perception for low-pitched sounds.

Paracusia, described by Willis, that is to say, improved hearing brought about by the influence of certain sounds, is often met with amongst workers in noisy workshops. These workers even possess the faculty of being able to talk to each other in an almost normal voice in an atmosphere found to be deafening by a visitor.

Forms of vertigo and discomfort, at times accompanied by nystagmus, nausea and vomiting, occur when perceivable vibrations are added to noise and when the worker is exposed over a long period to very loud and high-pitched or low-pitched noises (derangement of the vestibular apparatus). Glass-blowers, sailors, mountain guides, cyclists, motorists, miners, railway employees (especially mechanics and stokers), amongst workers engaged in the making of wines, amongst butchers (due to scratching with fingers soiled by meat juice, which is particularly irritating), divers, sponge fishers and caisson workers (during compression) may very frequently suffer from labyrinth derangements. The symptoms disappear in general very rapidly, but where there is haemorrhage or a lesion of the terminal nerve endings a certain degree of deafness may become permanent.

Derangement of the organs of equilibrium have likewise been noted amongst professional dancers, acrobats and music-hall artists (looping the loop). There should further be mentioned amongst occupational diseases of the ear neuritis of the auditory nerve, accompanied at times by hallucinations and acute labyrinthitis with Ménières symptom complex occurring during certain forms of poisoning (lead, mercury, carbon bisulphide, carbon monoxide, aniline, benzine, etc.: Westmacott).

Finally, it should be recalled that the clinical picture of certain infectious and parasitic diseases includes certain symptom complexes due to derangement of nutrition of the labyrinth (anaemia, ankylostomiasis, etc.).

II. — DISEASES OF THE NOSE

Apart from the action of noise, the sources of danger are similar to those described as leading to diseases of the ear.

PATHOLOGY

The most frequent trouble is nasal catarrh and catarrh of the upper respiratory passages, which constitute a defence reaction of the system since the humid mucous membrane arrests more dust and the inflamed mucous membrane restricts the passage of irritating dusts and gases. They cause anosmia or at least reduce the olfactory capacity, which is not to be confused with derangement of sense organs and of the sense of smell, which may arise in the course of general poisoning when the nervous system is involved.

The commonest form is catarrh.

Hypertrophic rhinitis with nasal obstruction is of frequent occurrence in occupations where workers are exposed to a damp atmosphere (weavers, cotton spinners: Della, Vedova, Westmacott), amongst workers engaged in the making of wines, amongst butchers (due to scratching with fingers soiled by meat juice, which is particularly irritating). Erosions, ulceration and perforation of the nasal septum are met with chiefly in those occupations in the course of which
workers are exposed to the action of certain irritant gases or fumes (nitric and hydrochloric acid, etc.), or certain hygroscopic products (lime, calcined spathic orres, chlorides, cement, etc.). Out of 165 workers engaged in sifting and packing salt, Müller found 45 suffering from nasal catarrh and 42 with perforation of the nasal septum. One of the most specific lesions is without doubt chronic ulceration of the nasal septum with or without perforation, affecting workers handling chromates or chlorates (see article "Chromates "), arsenical preparations (Scheele's green, Schweinfurt green, Paris green), or engaged in mercury gilding, etc.

Ulcerations and necrosis of the nasal cavity have been noted amongst workers due to contact with chromates, lime, hydrochloric acid, etc. There has also been noted rhinolithiasis due to agglomeration of dusts (cement).

Pains in the frontal sinuses are at times experienced by aviators (probably due to increased pressure inside the sinus).

Certain lesions of a traumatic nature are liable to occur to coachmen, stable-boys, sportsmen, etc. Others are merely symptoms of a disease affecting the general system. A typical example of this kind is constituted by glanders (see that article). The most common form is nasal catarrh due to cold, which is, according to Gottfried Müller, of two types. There is an aseptic form and an infectious form due to the action of dusts which affects not only workers in the open but sailors, boatmen and likewise workers exposed to high temperatures.

Nasal catarrh commences in general by itching and repeated sneezing. The symptoms are redness, inflammation, hypertrophy of the mucous membrane with nasal discharge and often accompanied by headache. At times there is epistaxis more or less intense, especially amongst young persons employed for the first time in dusty processes. Besides forms due to irritation, there is an anaphylactic spasmodic form caused by organic dusts.

In serious cases due to irritant gases there has been noted necrosis of a diphtheritic character affecting the superficial layers which have a whitish and at times a brownish appearance and become detached in strips (Sternberg). Thus for instance, ammonia at 0.18 mg. per litre of air (Lehmann) may set up intense inflammation of the mucous membrane accompanied by serous and blood-stained secretions. The epithelium, which is quickly sloughed off, reveals a bright red colour of the mucous membrane. Chlorine fumes cause ulcerations whilst hydrofluoric acid sets up particularly deep seated ulceration covered with white crusts which become readily detached.

Collis has noted, amongst granite cutters and grinders a smooth, dry and pale appearance of the lining membrane of the nose for the anterior quarter of an inch; behind this the membrane, which is probably covered with a crust of dust, is red and inflamed. More especially in the case of certain dusts—cement, for instance—the catarrh is accompanied by an eczematous condition around the nostril, which is probably an indirect effect of the nasal discharge set up.

Acute catarrh often develops into chronic catarrh involving atrophy of the mucous membrane accompanied by loss of the vibrissae. Dry atrophic catarrh is found chiefly in occupations where workers are exposed to hot dry air: laundry workers (ironing), spinners, firemen, blacksmiths, stokers, office employees (due to the action of central heating; Marschik). Atrophy of this type may lead to perforation of the nasal septum which is also noted as a consequence of the action of less harmful dusts: sawdust, cornflour dust, etc.

Traumatic anosmia is the subject of an interesting study engaged in by Woelk (1930). According to German statistics comprising 1,525 accidents, there occurred 738 cases of traumatism affecting the skull (48.53 per cent.), of which 265 (17 per cent.) showed disturbances of the olfactory sense. Out of 265 cases 63 individuals suffered from total anosmia, which was of traumatic origin in 44 cases or 2.9 per cent. (organic origin in 4 cases, functional origin in 17 and mixed origin in 23) and of a different origin in 19.

Anosmia, according to Onodi, may be of organic origin (essential, central or peripheric and respiratory), of functional or mixed origin.

Ziegler quotes the case of a worker who fell for a period of two seconds into a molten bath (sulphuric acid at 5 per cent.) and who suffered from total anosmia.

Cases of other than traumatic origin are not rare. They are met with consequent on infectious disease or following poisoning (by lead, mercury, carbon disulphide, iodine, etc.). Occupational pathology contains numerous instances of cases of anosmia met with amongst workers or employees in chemical products factories and due to
the inhalation of irritant or caustic fumes or gases (nitric acid, hydrochloric acid, chlorine, ammonia, etc.) capable of setting up olfactory disturbances. Whether and to what extent a lesion of this kind can reduce working capacity is a problem which calls for a solution in each particular case to be sought by extremely careful examination of the patient. On the other hand, there are occupations in which the sense of smell plays a very important role. Its loss or attenuation constitutes a serious hindrance to the occupational capacity of the individual.

III.—DISEASES OF THE LARYNX

For diseases of the mouth, see article "Mouth and Teeth".

Acute forms of laryngitis due to exposure to inclement weather, dusts, irritant fumes or gases, are generally manifested by alteration of the tone of the voice which becomes hoarse and by increased sensibility and dryness of the mucous membrane.

The oedematous form following inhalation of irritant fumes (chlorine, bromine, iodine, ammonia, sulphuric acid or even steam) is much more serious and may terminate fatally. Koelsch records a fatal case of chemical burning of the larynx by fumes given off in the course of soldering with copper and zinc where zinc chloride was used as a solvent.

The dry form characterised by atrophy is met with amongst washerwomen and workers obliged to work in a steamy atmosphere.

Chronic laryngitis is a frequent occurrence in occupations requiring vocal effort (artistes, orators, teachers and street vendors, etc.). According to Meyer, a particularly injurious effect derives from speaking in a falsetto voice or with a register other than a nasal intonation. Various lesions have even been met with: small ulcers and fissures of the mucous membrane located on the posterior surface of the larynx between the arytenoid muscles for which situation there is special predilection (Stoerk); erosion and softening of the mucous membrane, slight haemorrhages of the vocal cords (especially in the case of women and chiefly during menstruation); the "vocal knot" or knotty cord of singers, accompanied by diphyony (see article "Artists").

Symptoms of the larynx are also encountered in cases of occupational poisoning by certain products: paralyisis of the laryngeal muscles, for instance, in lead poisoning.

Tanquerel des Planches called attention to aphonia in horses in mines, sometimes necessitating tracheotomy, and Sajous has described adductor paralysis affecting a house painter, whilst unilateral paralysis of the adductors in plumbers has been described by Morell Mackenzie, and paralysis of the transverse and oblique arytenoid muscles which prevented approximation of the posterior ends of the vocal cords by Stiefer. Stoerk finally is said to have found laryngeal pachydermia amongst pork butchers as a consequence of excessive alcohol consumption— an affection likewise encountered in other occupations in which workers are subject to alcoholism.

Prophylaxis

The prophylactic measures to be adopted affect, in the first instance, the various sources of injury and should be effectively completed by medical examination of the workers on entering the occupation especially in the dusty and noisy trades. In this way it would be possible to eliminate individuals predisposed by functional or other defects or at least to call their attention to the risk involved by the special defects from which they suffer (hardness of hearing, labyrinth de-arrangements, etc.). This initial examination is all the more important since the majority of ear troubles, especially in the early stages, are ignored by those who suffer from them. The same is true of certain nasal defects: narrowing of the nostrils; obstruction due to polypi or adenoid growths which enforce mouth breathing and in consequence expose the subject to respiratory trouble. In this connection good vocational guidance makes systematic medical examination of the workers on a uniform plan essential (Peyser). There should further be indicated in detail the proper methods of medically examining the general system with a view to vocational guidance. Finally, it is essential to ascertain definitely the part played by middle ear affections in the causation of occupational deafness. According as to whether these exert a predisposing or protective effect, applicants for work affected should in fact be rejected or admitted.

Periodical medical examination at more or less extensive intervals, leading to the occupations and the requirements in question would also constitute a good preventive measure.
It is essential to investigate and ascertain the best method to be adopted universally for estimating auditory acuity in the workshop and determining the extreme limits of normal hearing compatible with the exercise of a noisy trade without examination by a specialist (Gilbert).

Gilbert considers that an international committee composed of doctors having free access to all the factories in their countries would be in a position to lay down the lines to be followed in an investigation into noisy trades.

Studies of this nature would require to be prepared in such a way that they might serve as a guide to otologists in their etiological researches relative to cases which they encounter.

Further, it is necessary to instruct the workers affected by means of lectures, tracts, posters, etc. A leaflet dealing with causes and prevention of occupational deafness due to noise has been published in Germany by the Health Office in collaboration with the German Association for Industrial Hygiene. This leaflet advises the workers in noisy trades to protect their ears by gauze plugs impregnated with vaseline or wax, to wear shoes with straw, cork, rubber or felt soles which attenuate the effects of vibration in the flooring.

Apprentices with hereditary history of ear disease should not be permitted to work in noisy workrooms. As soon as the worker becomes aware of troubles liable to be caused by noise he should be obliged to notify immediately the first symptoms which occur with a view to early and effective treatment.

The leaflet finally recommends the encouragement of every possible effort tending to reduce noise in workrooms and recommends that the possibility for workers to pass their spare time in quiet surroundings should be assured.

**LEGISLATION**

Ulceration of the nasal mucous membrane is subject to compulsory notification in the Netherlands when occurring amongst workers handling cement, packing chloride of lime or manufacturing soap powders and amongst workers engaged in the chrome and chromates industry. It entitles workers to compensation when caused by dusts in Great Britain, in Western Australia and in the U.S.S.R. (when affecting mud-bath attendants' and when due to manipulation of chromic acid). Hardness of ear and deafness are compensated in Germany, when due to noise in the metal industry. In the U.S.S.R. hardness of hearing due to lesions of the internal ear caused by the action of sharp sounds and affecting weavers, copper-smiths and nail makers is compensated.

The loss of the voice as a result of lesions and knots of the vocal cords is compensated in the case of singers and teachers in the U.S.S.R.

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**Dr. T. Ritchie Rodger**

(Hull).

**Occupational Poisonings**

(Physiopathology)


**DEFINITION OF THE TERM "POISON"**

A treatise, from a general point of view, dealing with problems concerning occupational poisoning must, in order to have any scientific value, first present a clear idea of the poisonous substance, and then analyse the various effects it has on the animal body, especially on the human body.

It is difficult to define a toxic, poisonous or injurious substance, although to the lay mind the meaning seems clear. Setting aside old conceptions, now long out of date, of physical poisoning, e.g. by glass or metal in powdered form, as opposed to chemical...
Poisoning, it has been the custom to think of a poison as a substance foreign to the human body and capable of injuring that body by means of its chemical action. This definition is not quite in accordance with facts and cannot be considered as complete. As a matter of fact, there are a great many substances capable of seriously injuring the human body, and in this way of becoming the cause of many common and serious occupational poisonings, which are normal constituents of the animal body, and in particular of the human body, or which at any rate are present nearly every day in food, although in small quantities: mention may be made of arsenic, and such heavy metals as copper, zinc, and even lead. But, in addition, the internal secretions, although constituting the normal products of the endocrine glands, under certain conditions of quantity and quality can seriously interfere with the functions of one or other system and lead to morbid syndromes which are clearly recognised and defined. On the other hand, some substances — for instance sodium chloride, which is so necessary for life — may in certain doses cause sickness or death, and may, under certain special pathological conditions, even be injurious in the ordinary amount used for food. Then, again, it is not by a chemical action only, but also by physico-chemical action, that many substances injure the body. Neither can it be considered, as is commonly done, that every substance is poisonous which may cause a functional disorder when introduced into the body in a small dose, for while that may be true in some cases and even for a great number of poisons, it does not alter the fact that there are some substances injurious in some doses, whilst in other doses they are not only inoffensive but necessary to life; such is the case with sodium chloride as just stated.

Thus, according to Flury, the degree of toxicity is not the attribute of a certain substance, but a relative idea, and, as demonstrated later, the difference between a poison and a medicine is seen to become more and more effaced. In fact it may be said that poisons and medicines both enter into chemical or physico-chemical reactions with the living protoplasm, so modifying its function in some definite way. If this functional disturbance is sought for, or more or less desired, and also is generally useful, the substance which produces it is given the name of "a medicine"; on the contrary, if this disturbance is dangerous and injurious, the substance is designated "a poison". Hence, in the present state of knowledge, it is not easy to formulate an accurate definition of the word "poison". In order to formulate one which, in a certain measure, serves to meet the case, reference may be made to that adopted by Biondi in his teaching, which resembles that of Starkerstein (it is also accepted by Flury and others):

"Exogenous substances and endogenous substances in the body are to be regarded as poisons, which, on account of their chemical or physico-chemical action, and by their quality, quantity and concentration, which differ from those of the body itself, or from one particular organ, are capable of causing functional troubles in the living body."

Hence, in order to define what substances are toxic and capable of causing occupational poisoning, there must be considered as such certain substances possessing the above-mentioned characteristics and properties and found in the materials handled, in the products, in the tools, or in the work-place. These are the sources of poisoning of chief interest as they cause the morbid conditions of which it is necessary to estimate the seriousness in relation to work.

Thus, it must be admitted that besides voluntary poisoning, in which the action of the poison is desired by the taker of the poison, the source of the poisoning must be sought either in an accidental act, which may sometimes come under the legal definition of an industrial accident, or in some condition during the normal progress of a particular piece of work which may lead to occupational disease, or in an act, due to the fault of others, which may come under the designation of delinquency or semi-delinquency.

Portals of Entry for Poisons

When dealing with the portals of entry for poisons, as a general rule there is included the subcutaneous, intramuscular, endovenous, rectal and vaginal paths. But in the case of occupational poisonings there need only be taken into consideration the cutaneous path, the mucous membranes, the digestion, and the air passages.

For a long time, even up to recent years, the general opinion was that in man it was not necessary to consider the healthy skin as a portal of entry for poisons, at least not for industrial poisons. It was believed that the skin, being covered with a thin layer of fat, could not be penetrated by substances dissolved in water, and as
it was thought that substances insoluble in water could not usually be absorbed. The intact cutaneous path was considered the only portal of entry for these substances, but experience has, however, shown that these theoretical conceptions differ from the true facts; there is no denying that, if the epidermal cells of the cornal layer and of the stratum pellucidum with their fatty surfaces or lipoids, prevent the absorption of substances dissolved in water, it does not mean that these solutions cannot penetrate by means of the openings of the sebaceous and the sweat glands, and that by these paths certain toxic substances cannot be absorbed, even in small quantity.

It does not mean either that there cannot be other conditions, unknown at present, but which may, independently of these factors, lead to the absorption of aqueous solutions through the intact skin. One of these conditions may be represented by the alterations which the corneal layer undergoes on contact with certain substances, as for example salicylic acid and phenol. These substances are the most serious obstacles to the absorption of aqueous solutions. Then again, there can be no doubt about the possibility of absorbing through the skin substances which are soluble in organic solvents and, especially, in fats and lipoids. In this way the absorption of anilines and nitro-benzenes is understandable, as well as that of mercury and lead, although until quite recently this was denied. Some gases also undoubtedly pass through the healthy skin, e.g., hydrocyanic acid; the volatile fluid, tetraethyl lead, can also penetrate the skin.

The mucous membranes present a more favourable medium than does the skin for the absorption of poisons; but, from a practical point of view, in the domain of industrial poisons they do not play any particular part. The conjunctival mucous membrane should be specially mentioned, but the reason why the penetration of poisons by this route is of less importance is easily understood; whilst, on the other hand, the mucous membrane of the digestive and respiratory apparatus should be taken into consideration at the same time as the respective systems.

The various parts of the digestive apparatus are all capable of absorbing poisonous substances, but in different degrees, which perhaps also depends on the nature of each of the substances (Meltzer). Absorption may also occur by the mucous membrane of the mouth, although it is not usually considered; in the same way the entrance of poisons by the oesophagus and rectum may lead to more important toxic effects than those which occur by other parts of the alimentary canal, a doctrine being made for the absence of the antitoxic effect of the liver, and for the fact that the venous blood from the mouth, oesophagus and rectum does not pass through the _vena cava_, as does that from the stomach and small- and large intestine.

Also, as regards the alimentary canal, it was maintained up to a few years ago that only substances soluble in water can be absorbed. In this way the possibility of the absorption of numerous industrial poisons was denied; and it is well known that a distinguished industrial pathologist, Hambousek, denied that pure lead sulphide could be absorbed, while all the time Biondi was able to demonstrate experimentally its absorption by the alimentary canal. These theoretical presumptions fall one by one before experimental and clinical proof, and it is now known that the gastrointestinal channel is open also to industrial poisons which are insoluble in water.

The third portal of entry for industrial poisons — not merely for those in the state of gas and fumes — is the respiratory passages. The absorption of gas takes place essentially through the epithelium of the pulmonary alveoli; and its intensity can be understood considering the enormous surface — several tens of square metres — represented by the pulmonary alveoli. But absorption by the respiratory passages is not so simple as appears at first sight, even in the case of gases. First and foremost there is the reflex stimulating the terminations of the sensory nerves and, in particular, of the trigeminal, especially in certain conditions of special neuro-vegetative vagotonic action, can cause arrest of the circulation and respiration sufficient to bring about rapid death, while giving the erroneous impression of a toxic asphyxiating process which has never occurred (Bianchini and his pupils). There are also gases which cause an intense congestion of the mucous membrane of the pharynx, trachea and bronchi, and others which become decomposed on coming in contact with the salt humidity of the epithelium of the bronchial mucous membrane and alveoli, so that a local action is produced, without any absorption occurring; this is so with chlorine and phosgene. In this case there is a mechanical asphyxia caused by the local conditions of the toxic substance and not a general action of the poison on the whole body.

The mechanism for the entrance of poisons contained in toxic dust is still uncertain from several points of view. This fact is of great importance in occupational pathology, for it is well known how common it is for the dust of workshops, foundries and mines to contain poisons. It was at first agreed that dust could be harmless as regards its toxic effect if the dust was fixed by the interalveolar connective tissue or the glands of the hilum, where it was believed that it remained as an inert deposit. But against this conception there was set existence of signs of poisoning in persons who had absorbed certain poisons. It was thought then — and some experiments of Romby, made in the Biondi Institute have confirmed it — that a certain quantity of inhaled dust, and even the largest part of it, was swallowed and passed into the alimentary canal. Further investigations of Biondi (Italian Congress of Labour Pathology, Florence, 1921) have shown that even granules of insoluble toxic material, while they remained as an inert pneumonocoriotic deposit, can by some mechanism that is not yet clearly
understood become dissolved and pass into the circulation.

THE ACTION OF POISONS ON THE BODY AND OF THE BODY ON POISONS

The study of the action of poisons on the animal body presents great difficulties. It was first believed to be due to a pure and simple chemical action, in the sense of a combination between the poison and living protoplasm or the body fluids. It is true that some of these chemical combinations explain the action of some poisons, e.g. of those which combine with haemoglobin. On the other hand, it is equally true that, in the physiopathology of poisonings, it is necessary at the present time to look for other mechanisms of action which are not purely chemical — the action of electrolytes, the effects of osmotic action, of changes in colloidal state, and of the phenomena of absorption — which necessitate taking into account the physio-chemical actions of poisons.

There is no doubt of the serious difficulties which confront those studying the various kinds of action of poisons and their point of attack on the various tissues and organs. As Flury has observed, the cells and the tissues cannot and should not be isolated from their environment, it being granted that the conditions of their functioning depend on the environment, for the cell in its environment represents a biological unit. Thus, when studying the action of poisons, it is necessary to take into account, in addition to the direct reactions between the tissues and the poison, other conditions in the body, modifying the physiological oscillations between the cells and their environment. The osmotic equilibrium between the cell and the body fluids, the colloidal state of organic liquids on the surface of the cells and within them, and also the composition of the blood, are under the influence of variations in ionic charge which can be modified by the action of poisons. In their turn, variations in the internal secretions and in the reactions of the vegetative nervous system can be the cause and effect of the variations in the ionic charge of the body fluids, and, in consequence, the cause and effect of a varying action of the poisons. Cellular poisons, when they do not arrest the functions of the cell, activate them as catalysts, or weaken them, acting not in a qualitative way, but a quantitative. It is thus that the same effects can result from their action as can be obtained by electrolytes, such as calcium and potassium. Hence, according to Zondek, the actions of the vegetative nerves, those of electrolytes and those of exogenous and endogenous poisons, among which are included the internal secretions, may be substituted the one for the other.

In the action of poisons, therefore, quite a number of phenomena are produced which constitute a chain, and it is not always easy to identify the different links, let alone to understand them. For the present, the most important links will be chosen, and attention will be withdrawn from theoretical ideas which are employed in attempting the decomposition of complex actions into their various stages. In the case of occupational poisonings, what is more important is to fix as basis for the above considerations, as shall be seen better further on, that the physiopathology of the exogenous poisons may be identified, not only with that of certain endogenous poisonings, but with variations otherwise produced in the ionic charge, in the production of internal secretions and in the functions of the vegetative nervous system.

In trying to split up these physio-pathological processes it also becomes possible to understand by what means there may be superimposed on, or even substituted for, that which is actually, in force, a classification of poisons which essentially takes into account physio-toxic action in the light of new physio-chemical facts. As a matter of fact, a classification of poisons according to their chemical composition cannot be sustained, even though at the present time it might seem hard for lack of data, to fix as basis for the classification of substances the same chemical composition which are diverse in toxic action, and others, such as curari and camphor, which act in a similar manner without having any chemical resemblance. A classification according to the point of attack of the poisons cannot be upheld any more than the other, either on account of lack of knowledge or on account of interfering modifications in the functioning of one system reacting on that of another. In this way a mixed classification has been arrived at, which takes into account the pharmaceutical action and the point of attack, with a purely empirical orientation.

It may be said that the action of the ions characterises, at least in part, many of the toxic reactions — that of acids, bases, and salts being represented by their ions. The acids dissociate hydrogen ions and the bases of hydroxyl ions. In this way the...
acids and acid salts have a common type of toxic action, which is in accordance with the hydrogen ions: at a certain concentration the pH of protoplasm and the body fluids is lowered, and in consequence there is such increased action of all the processes of metabolism as to constitute a catabolic stimulus.

This modification of the pH of the body fluids causes phenomena of stimulation of the vegetative nervous system, especially of the respiratory centres, and — when certain limits are reached — symptoms of paralysis, until that state of stable equilibrium is reached which is the death of the cell. This state is rapidly attained in local actions, when a certain concentration in hydrogen ions is attained. With acids soluble in lipoids there is rapid penetration into the interior of the cell, so that the functional and structural disturbances are more marked than with mineral acids which are not soluble.

Alkalis act in an antagonistic manner to acids, by dissociating hydroxyl ions. The pH increases when the various buffers do not any longer suffice to maintain the acid-basic equilibrium of the body fluids and the protoplasm within ordinary limits; there results an alkalosis, together with a slowing of the metabolism, and tetany. The action of alkalis resembles more or less, as regards neutralisation, that of salts. Thus, the alkaline carbonates are less active than the hydroxides in consequence of their less electrolytic dissociation.

The intensity of the action of acids, bases and salts depends then, on the one hand on the degree of their electrolytic dissociation. On the other hand, the toxic or antiseptic strength of numerous mineral and even organic compounds is associated with their state of dissociation: when, for example, the dissociation of the salts of mercury diminishes, their antiseptic power diminishes also; mercuro-potassic thiosulphate is not poisonous for cold-blooded animals, for the mercury in that case does not become ionised. But, at a higher temperature, the mercury ion dissociates and becomes poisonous for warm-blooded animals, the blood temperature of which is higher.

In addition to electrolytic dissociation and the molecular concentration of organic liquids, the action of the salts must be considered, which, like that of acids and bases, depends also on the special chemical properties of their ions. Hence, the kations of metal and the anions of acid can take part in the toxic action of their salts. The action of the ions, however, is in accordance with their valency, and is exerted, for example, on colloids and, very probably also through them, on enzymes in proportion to the raising of their valency; hence the antagonism between monovalent potassium and bi-valent calcium, and the possibility of substituting sodium for potassium, both being monovalents.

In the case of the salts of heavy metals, the physico-chemical action of the salt takes place in accordance with the toxic action of their ions. Metallic albuminates, formed by the contact of metallic salts with organic tissues, lead to the death of the cell; if they are insoluble they form a kind of protective barrier for the deep tissues; if they are soluble they act at a depth. The general toxic action is in relation to the solubility of these complexes, their concentration, the degree of dissociation and their chemical properties. Thus, the strong toxicity of the salts of mercury and lead can be understood in proportion as there comes into play the solubility of the fatty acid salts of lead in lipoids.

Another kind of physio-chemical action, in addition to the purely chemical one, is exercised by poisons of the nervous system, some of which, although more restricted in number than the others, concern occupational toxicology. The action of narcotics has been attributed essentially to their solubility in fats and lipoids, in order to explain their tendency to accumulate in tissues rich in fat — to which belongs the nervous system — and also their paralysing action, and, in some cases, painless poisonous actions, which succeed each other in the various sections of this system. At present the tendency is to attribute much importance to the phenomena of adsorption in the mechanism of the physio-toxic action of narcotics, and in the action of most poisons of the aromatic series. These poisons react particularly with the nerve cells and exhibit an action resembling that of narcotics, even though the paralytic phenomena are sometimes masked by phenomena of excitation, and though the order in which the various sections of the nervous system are attacked is different. Further, special chemical actions are accepted, just as they are accepted by hypothesis in the case of alkaloids, the free bases of which, with their complex molecules appear to be readily soluble in fats, lipoids and adsorbables. It has, however, been thought that, in the action of alkaloids,
another modality comes into play, which explains better than other hypotheses the fact of the elimination of certain alkaloids, after their reactions, without any change in their structure. Here it is thought that the penetration of the large molecule of an alkaloid into the liquid contained in certain definite cells does not cause chemical changes therein, but only a disturbance of the physical equilibrium constituting the basis of the normal functions of the said cell. Thus changes can be produced in the physiological condition of the solution of protoplasmic substances which perhaps may lead even to flocculation.

In this way it can be understood that once a foreign alkaloid substance has made a timely disappearance, reversible disturbances may cease, provided that the circulation and nutrition have remained normal between times.

All poisons which do not exert merely a local action naturally pass into the blood, and circulate there, usually without undergoing any particular changes. Others, on the contrary, and they include the blood poisons properly so called—act on the constituent elements of the blood. At present, as regards their action, there are known only those which act on the red blood corpuscles and the haemoglobin. The "haemolytic poisons", acting on the red blood corpuscles, do not develop their action through variations of the osmotic pressure as is the case with hypotonic solutions, which, on the other hand, when introduced into the alimentary canal, do not succeed as such in penetrating into the blood stream. These poisons convert the chemical or physico-chemical state of the membrane of the red blood corpuscles and, speaking more accurately, of the densest peripheral part of the erythrocytic protoplasm into the essential colloidal and cholesterinic components. Among these poisons arseniuretted hydrogen is the one which concerns industrial pathology most. That haemoglobin dissolved in the blood plasma can give rise, apart from haemoglobinuria, to pleiochromic or so-called haemolytic jaundice, is generally recognised today.

Some authors are inclined to adopt the opinion, without sufficient grounds, that another action is produced on the red blood corpuscles, this action being that of some poisons and principally, if not exclusively, of lead, leading to the formation of special granules in the red blood corpuscles. This hypothesis is definitely upset by the researches of Blanchini, who, after treating red blood corpuscles in various ways, only obtained basophilic granulation in the case of young elements containing granulo-filamentous substance detected by vital staining. The only conclusion would seem to be that lead poisoning may cause special physico-chemical conditions of the plasma of poisoned animals, so that in the fixed preparations the endoglobular chromatophile of the not-fully-developed red blood corpuscles shows itself in the form of basophilic granulations (punctate red globules) rather than by a diffuse basophilic of the element (polychromatophile red globules).

The poisons acting on the colouring matter of the blood form with it a chemical combination incapable of giving up oxygen to the tissues. The best known and the most common poison of this group is carbon monoxide, which has for haemoglobin an affinity two hundred times higher than that possessed by oxygen. Carboxyhaemoglobin does not give up oxygen to the tissues as oxyhaemoglobin does. Other poisons change haemoglobin into methaemoglobin, another oxygenated combination incapable of yielding up oxygen, except in the smallest quantity. The poisons of haemoglobin properly so called, such as aniline and potassium chlorate, form methaemoglobin directly; others, on the contrary, form products capable of leading to the formation of methaemoglobin by various processes: by oxidation, as the phenylhydroxylamine of phenylhydrazine; by reduction, as the hydroxylamines of the aromatic nitro-compounds; by splitting up, such as the dioxybenzenes of the phenols.

There are also poisons described under the name of "cellular poisons", which exert their action second-hand, so to speak, by a functional disturbance, or by signs of inflammation at the site of their application, or in the immediate vicinity. All these substances are really capillary poisons and act essentially through the products of the cellular destruction which they occasion.

This account, though brief of the modes in which poisons act when seen in the light of modern biological developments, makes it comprehensible that the symptoms of poisoning, and in particular those of occupational poisonings, may sometimes have no characteristic, and merge not only into the symptomatology due to endogenous ills, but especially also into excessive, faulty or scanty internal secretions, but also into the phenomen-
metatoxic, which are produced at a play, apart from the phenomena called no way connected with exogenous poi-

and of other conditions, which are in endothelial proliferation in the fibroplastic direction, Institute have shown how toxic phenomena persist after the poison has been com-

versed as that special condition which Heub-
distance from the absorption, as well as one can understand how func-
tionaldisorders, secondary to those cause in a secondary way, through changes may be incapable of causing characteristic action of poisons,

what has been already written on the action of poisons, it may be seen how undecided this idea is. In reality it can be understood why some doses of poison may be incapable of causing characteristic symptoms, although they may be able to cause in a secondary way, through changes in the cellular equilibrium or in the internal secretions, diseased conditions which have no definite toxic character. The idea of a fatal dose should not be taken in the classic sense — that is to say, the idea of a dose of toxic substance which is able to cause rapid death — but of a dose of poison which is able to cause death either directly or indirectly with more or less rapidity. It is not necessary either for the toxic dose or for the fatal dose to depend strictly on the quantity of poison which is introduced into the body at one time, or at several different times in succession. It is certain, at least as regards occupational poisonings, that it is not necessary to stop to formulate figures of toxic doses and of fatal doses for various poisons, but it is necessary rather to consider only the morbid changes found which can be caused by a given substance.

It should be borne in mind that with certain doses of numerous poisons an action is developed which, especially as regards repercussion on the functions of the vegetative nervous system, appears as antagonistic to that which is developed after other doses. Thus it is that poisons may act in weak concentration as stimulants of various organic functions, while in strong concentration they may inhibit them; arsenic, for example, is a typical poison of metabolism; calcium in certain doses does not develop the sympathethico-mimetic effect which is obtained very definitely with bigger doses (hariath); and ergotamine is a sympathetic depressant which, as Biondi has been able to observe, becomes a sympathetic stimulant in small doses.

**Toxic Synergism and Antagonism**

Two eventualities may take place when different poisons act on the animal body. One, perhaps the commonest, is that in which the effects of two poisonings are added to each other. These phenomena of synergism, or of the respective reinforce-

ment of different poisons, have a notable importance, especially in occupational pathology, not only as regards such mixed poisons as sulphuretted hydrogen and carbon monoxide, which cause poisoning which would not be expected, taking into account the percentage of each of the toxic gases in the atmosphere. As a matter of fact industrial pathology deals most fre-

quently with the synergisms, on the one hand, between occupational poisonings and volunitary poisonings, and, on the other hand, between occupational poisonings and other injuries as cold and snow poison.

About twenty-five years ago Biondi demonstrated experimentally, in animals poisoned by lead, a lowered resistance to the effect of alcohol; and, about the same time, by histological research Donaghe demonstrated changes in the neuro-fibrils of the cells of the grey horns of the spinal cord, caused by the combined action of cold and alcohol, two types of causes which, taken separately, were incapable of causing them.

Other poisons, on the contrary, acting together, may exercise an antagonising effect. Carbon monoxide has an affinity for haemoglobin much greater than has oxygen; the effect of carbon monoxide on haemoglobin, however, can be influenced antagonistically by carbon dioxide. at strong concentration, causes the carbon monoxide to be detached from the haemo-

globin, when it displaces it (Haldane). The action of a magnesium salt causes a

anoxia which the intervention of a calcium salt does away with; the action of muscarine is antagonistic to that of atropine. These antagonisms should not, however, be confused; that is to say, the physio-toxic should not be confused with
the chemical antagonisms which are not antagonisms properly so called, but only represent mechanisms of defence of the animal body. Among these last should be noted the substances called "stabilisers" or "buffers" which tend to restore the acid-base equilibrium upset by the action of acids, or of alkalis, and the formation of compounds less toxic than those of the substances already introduced. It is necessary to deal somewhat systematically with this defensive machinery.

Elimination of Poisons

The first means of defence which the animal body possesses against poison is that of elimination. That does not mean to say, as shall be seen further on, that particular lesions may not occur due to the failure of elimination and at the site at which it occurs. Poisons may be eliminated in the form in which they were introduced or quite changed. In the second case, after elimination, special processes of oxidation, reduction and decomposition occur, concerning which details must be given.

The first and most important of the mechanisms for the elimination of poisons is that which comes into play before absorption occurs, or when that occurs to a very small extent. This eventuality, which is represented by vomiting and diarrhoeic stools, is rarely met with in occupational toxicology, and it is not necessary to dwell on it here. So attention must be exclusively directed, as already stated, to the elimination of poisons already absorbed, which are eliminated in their original state, in the first place by the kidneys. They are chiefly the crystalloids, i.e. salts of all kinds; they are eliminated by the urine, which, however, also passes other toxic substances. Elimination by the kidneys is effected more or less rapidly depending on the substances and on the condition of integrity of the body, and also depending on the intervention of other substances which are able to accelerate it, such as sodium chloride, iodides and sulphur, in the case of heavy metals. The passage of certain poisons through the kidneys is not, as has been stated above, without effect on that organ; and renal lesions (nephroses) which are caused by the elimination of such heavy metals as mercury and lead are well known. All the glands of the alimentary canal, from the mucous and salivary glands of the mouth and glands of Lieberkühn and of Brunner, and those of the rectum, take part in the elimination of nearly all poisons, especially of the metallic poisons. It is not difficult to confirm up to a certain point that there may be a vicious circle, in the sense that part of the poison which is excreted into the intestine may be reabsorbed afresh. Elimination through the intestine explains the production of certain ulcerative lesions, which were at first attributed to the effect of contact with the poison which entered the alimentary canal, although they were observed equally when the poison was introduced into the body by parenteral entrance.

The elimination of poisons through the mucous and salivary glands of the mouth demonstrates the mechanism by which are produced certain phenomena which are of great importance in the diagnosis of occupational poisonings, such as the blue line on the gums in lead poisoning, and ulcers or gingivitis in those poisoned with mercury.

Another path for the elimination of poisons, which is not confined to volatile poisons, as is believed, is by the lungs. For this particular method of elimination, valuable diagnostic criteria exist for some occupational poisonings, based on the particular smell which the breath of some poisoned persons has. It is sufficient to give, as an example, the case of the smell of garlic from those poisoned by arsenic.

Numerous poisons, and not only the volatile ones, are eliminated by the skin. It is known that in consequence of this elimination special chronic acne lesions are caused, and that the skin may take on special colouring in certain poisonings, as in that by silver. It is, however, still doubtful, as was pointed out by Blondi in 1921, whether there is a pale, dirty tint of the skin due to lead. It is also to be noted that arsenic only reaches the hair tardily, through which it is eliminated very slowly.

Another path for the elimination of poisons, including several occupational poisonings such as lead, mercury and arsenic, is that of the lacteal secretion, which must be remembered when women who are breast feeding are employed on work which involves risk of poisoning from lead, mercury or arsenic.

Accumulation of Poisons in the Body

Poisons are deposited differently in the various tissues and organs before being eliminated with more or less rapidity and being transformed more or less radically. The site of deposit varies with different poisonings, and from one cell to another. It is known that the superficial layer of the cell possesses the power of retaining certain ions and certain molecules, and of allowing some others to pass. In this way is understood the phenomenon, confirmed to-day by biology, of the prevalence of the ions of potassium in the interior of the cells and of ions of sodium in the body fluids. Naturally, it happens that some poisons are deposited in certain tissues and organs, some in others. In some cases, by the activation of processes which will be discussed further on, poisons deposited in certain organs, e.g. in the liver, are changed and rendered harmless, or in any case less injurious. In other cases the poisons are retained, so to speak, indefinitely, for example in the case of arsenic in the hair. In other cases again, there is a gradual process of bodily elimination. In other cases again, and particularly in the case of lead, as Blondi and his followers have shown, there is an elimination by fits and starts which...
sometimes takes the character of a mobilisation of the poison with a repetition of toxic symptoms, set going by intercurrent events, such as malarial attacks, injuries or changes of metabolism. Blindi was able to detect in some old varnishes of Sienna, at intervals, lead in the urine, even twenty years after the last possible source of poisoning, and this after the administration of iodide preparations, or even without any apparent cause.

**The Defence of the Body against Poisons**

Poisons which are not eliminated may be rendered harmless by means hitherto mentioned several times. In speaking of the action of acids, alkalis, and salts, there has already been described how the maintenance of the acid-base equilibrium of the body fluids, when threatened by a lowering or raising of the pH, in consequence of some increase in the hydrogen ions, or in the hydroxylic ions, is assured by the different buffer machinery.

There have also been mentioned the processes of oxidation which are confirmed, for example — if it is desired to refer to an industrial poison — by sulphuretted hydrogen. It is known that in poisoning by this gas, sulphite of soda is found in the circulation, and that it can be changed into the sulphate. There may also be reducing processes, as is the case with poisons of the aromatic series; and processes of more complex detoxication falling into the group of chemical syntheses; and yet others — of which scarcely anything is known — due to the activity of the cells of certain glands and especially of the liver.

A process of detoxication, due neither to buffers nor to chemical processes, is the purely physical one of adsorption, the importance of which is more and more accepted, especially in the domain of occupational toxicology, when, as is known, small quantities of poison are absorbed; for it is notorious that more of a dilute solution is absorbed relatively than of a concentrated solution.

**Mithridatism**

The presence of a poison in the body and even its return into the circulation from deposits, where it has accumulated, does not have as a constant and progressive effect the appearance of toxic symptoms, which remain with an intensity proportional to the dose of poison which has obtained access, no matter how, into the circulation. It has been known for ages that the body develops tolerance of certain poisons, and that stronger and stronger doses can be introduced with more and more attenuated results.

Mithridatism is the name by which this faculty of becoming inured to poisons is known, because it was perhaps on the body of Mithridates that, according to the legend, the knowledge of this singular tendency was established; it has not found any univocal explanation, and still less a definite illustration. It is probable that the processes by which the phenomena can be verified are various. First of all it was considered, and recently Cloetta has returned to this way of thinking in regard to arsenic, that the absorption of poison becomes less with time, as if barriers were opposed to it at the points of penetration. But Joachimoglu has not been able to confirm the researches of Cloetta, having aside the possibility that the phenomena of acquired resistance might be related to a diminution of the intake of poison, it was thought that such transformation of the poison might be produced in the body as was able to render it harmless.

As regards morphine and alcohol, it has been attributed to an increase in oxidation; and as regards camphor to an increase in its combination with glycuronic acid. But these hypotheses, even if they are confirmed, are not sufficient to exclude the fact that, in those cases there has also been an increase in the cellular resistance to the different poisons. For example, as regards alcohol, there is proof of this increased cellular resistance in the fact that alcoholics react with less sensibility to the action of narcotics of the fatty series, such as ether and chloroform. It was then thought that allergic phenomena came into play on the entrance of the poison; where in the case of numerous poisons, e.g. metallic poisons, it seemed impossible to admit antigenic qualities, it appeared that there might be some idea (Centanni) either of meta-antigens, resulting from the combination of poisons with proteins, or of other derivatives. It was estimated that with these meta-antigens it was possible to obtain meta-antibodies, capable of rendering the poison inoffensive. However, the hypothesis of allergic phenomena, even thus corrected, cannot be admitted, at least for industrial poisons; and some unpublished experiments undertaken by Catarzi in the Blondi Institute have dissuaded him from pressing it.

Recently a series of researches engaged in by Bianchini and his pupils
have proved that in defence against metallic poisons introduced in molecular solution, the reticulated endothelial system perhaps also plays a part by the mechanism of adsorption. The function of this system can be activated by increasing the surface by the introduction of suitable doses of colloidal metals. This defensive action of the reticulated endothelial system has been demonstrated in the Biondi Institute by Francioni as regards mercurial fumes. He has, as a matter of fact, been able to decompose the physio-toxic action of the poison in question as regards both its entity and the defence of the reticulated endothelial system; for it seemed to him that the protection against disorders affecting metabolism should be attributed to this system, whilst it would not play an appreciable part in the extra-pyramidal lesions (tremors).

These observations certainly open up large horizons for knowledge regarding the phenomenon of becoming injured to poisons, which, as regards such heavy metals as lead, mercury, zinc and antimony, is the most common source of occupational poisonings — has been denied by numerous authors, although several clinical and experimental observations of Biondi gave an irrefutable demonstration thereof twenty years ago.

CONSTITUTION AND POISONING

In addition to the defences which the animal body can set in action against the effect of poisons, by the help of our processes or another there are conditions still unknown, in which certain individuals do not feel the effect of some poisons, whilst there are others who present a special and exaggerated sensibility to their effects. There is thus a question of some particular resistance to the poisons, as of a hyper-sensibility or of an idiosyncrasy; and it has even been affirmed that some families transmit these special peculiarities in an hereditary way. Others affirm that there is a hyper-sensibility resulting from age, from a decadent condition, or various diseased conditions, and from occupational and voluntary poisonings, which are capable, as has been noted several times already, of rendering an individual more sensitive to the effect of other poisons. It has been further observed that some poisons exert on some individuals an effect not only more or less intense than on others, but more or less at variance with their ordinary effects.

These singular phenomena have been, and still remain, in some degree mysterious. However, new doctrines on the constitution, which have a very firm biological foundation, in spite of the objections formulated with regard to them by those who do not know them and by those who make bad use of them, open the way to clear and sure explanations of the facts. Naturally the constitution must be considered in a wide sense from the somatic and biotonic points of view, from the point of view of the dominating hormone and the neuro-vegetative tonality and the ionic charge. Viewing it thus as a whole, it may be understood that, for example, the haemoglobin poisons — from carbon monoxide to potassium chlorate — may have more serious effects on katabolic individuals than on anabolic; for in the first the basal exchange is higher, and in consequence the oxygen requirement is greater, whether one wishes to regard the action on the tissues as direct, or as assisting dehydrogenation. It would then be understood why the acid poisons, which dissociate hydrogen ions, lead to more serious effects on individuals in whom there is a constitutional tendency to acidosis with lowered pH; and why the alkalis which dissociate hydroxylic ions are more active for some individuals with high pH, and inversely. It may also be understood, on the other hand, according to the researches of Bianchini, why anabolic subjects are more resistant to the action of lead, it being granted that the very great hydrophilia of colloids characteristic of these individuals, would make one expect that their reticulated endothelial system would be quicker to defend itself against metallic poisons. This hypothesis falls into line also with the researches of Biondi on the action of plomberous plasma, which in vitro favours the development of cultures from the reticulated endothelium in the fibroplastic sense, for it is known that the internal secretions which stimulate the formation of connective tissue are those of the anterior part of the hypophysis and of the chromaffin system, which do not predominate at all in the anabolic type.

It would likewise explain why sympathetico-trophic poisons cause more serious phenomena in the case of strong and weak sympathetic systems than with strong and weak vagus systems, and inversely for the, vagotrophic poisons. It is understood how the poisons of the brain have more severe effects in medium weak individuals than is met with
especially among the anabolics. It would also provide an explanation of the fact that poisons which are eliminated by the bile have a less effective action on the constitutional types with a neuro-vegetative direction towards para-sympatheticus, in whom the elimination of bile seems more rapid.

Examples could be multiplied and other tempting hypotheses could be formulated. However, concerning constitutional problems, as for all arguments still and always in process of evolution, it is essential to proceed with all reserve. Nevertheless, sight must not be lost of the luminous track from which irradiates the promise of so many fruitful directions for the prevention of occupational diseases.

With this in mind, it is necessary to collect clinical observations in regard to the constitution, as many as possible, by way of explaining the reasons for idiosyncrasies and resistances, and to seek by experiment to illustrate the neuro-vegetative conditions, both hormonal and electrolytic, which modify the action of poisons and especially of industrial poisons.

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(Sienna).

Odours


The cause of a substance having an odour is not yet known; it is further not known how to establish a relation between chemical composition and the odour of substances. In practice odours are classified according to characteristics they produce on the senses.

The intensity of odours is very variable; it is very strong for certain substances (musk for example), intense, strong or faint for others. Faint odours, however, for example that of vanilla, may have great penetrating power. Beaunis classifies odours in two categories: perfumes with considerable strength, of which musk is the type, and intensely active odours or odoriferous substances, of which mint is the type; both act on the olfactory nerves. Further, the same expert distinguishes between substances which act at the same time on the olfactory nerves and on the tactile nerves of the pituitary mucosa (for example, acetic acid) and substances which act only on the tactile nerves (for example, carbon dioxide).

Odours are distinguished one from another by quality, which is intimately connected with the molecular structure of substances of the same chemical series. There exist, however, substances apparently inodorous, but possessing odours which civilised man cannot detect.

The substances which are odoriferous are generally volatile. It is then probable that particles liberated from these substances are dissolved in the mucus which covers the olfactory region and act chemically on the olfactory cells. These cells represent true nerve cells situated in an epithelium and, according to embryological and histological studies, are elements similar to the nerve cells of the spinal ganglia.

Nerves of the upper part of the nasal fossae act only for olfactory purposes; but it is difficult to say if there are special receptors or conductors for the different and principal causes of olfactory impressions.

This point seems to have a definite answer, for persons are met with who, while recognising all the other odours, cannot recognise the smell of violets or vanilla (Gley). Investigations made on partial fatigue of the olfactory sense confirm this thesis, as the olfactory sense, when fatigued by a definite odour, remains sensitive to other excitants (Aronsohn, Zwaardemaker, quoted by Gley). Odoriferous particles are transmitted by air and water, but it is necessary for both to be sufficiently charged with odoriferous particles and for them to act for a definite period, which is always very short.

Although by training the delicacy of the sense of smell can be increased, habituation does not always develop the sense, but may diminish the
keenness. As a matter of fact, workmen employed in offensive smelling occupations do not in the end notice anything offensive.

**Origin and Action of Odours**

Odours may have one or several origins; thus, for example, they arise:

(a) from collecting and working up animal matter; when assembling animals and offal; at abattoirs, places for tripe boiling, stores for meat, debris and offal; at knackers' yards; at accumulations of filth, sewers and manure pits; from the treatment of animal residues, for example, in the manufacture of glue and chemical manure; and from threshing and washing of wool;

(b) from warehousing and manipulating certain vegetable substances while threshing, carding, and washing hair, hemp, flax, and feathers for bedding; in breweries and in roasting coffee on a large scale;

(c) from the warehousing and use of mineral materials in stores for asphalt, bitumen, and of solid bituminous materials.

In addition to fumes there are gases and vapours of offensive emanations, which are given off during certain industrial operations. It is, above all, the presence of gas, such as sulphurous anhydride, ammonia, sulphur- etted hydrogen, etc., which make these emanations troublesome.

Then there is a series of emanations which are caused by the mixing of several gases or odours in which it is very difficult to identify the special odour present.

Offensive odours are generally due to decomposition of organic material.

Although odours are the least dangerous of the troubles met with in industry, yet most of the factories which are registered are registered for this cause.

As a typical example of a smell emitted in the course of industrial operations, we may mention the extremely disagreeable smell of mercaptan. This substance is produced when sulphonal is prepared by heating sulphide of sodium with ethyl sulphuric acid.

Quite apart from smells which cannot be eliminated by industry, there is a long series of those which are not necessary and can be easily eliminated. They are especially smells arising from the accumulation of organic materials.

But when speaking of odours, odoriferous substances or perfumes must not be forgotten. These may damage the sense of smell and cause troubles among the workmen who make or handle them. As a matter of fact turpentine, ether, camphor, coumarine, safrol, nitrobenzene, and the whole series of essential oils are not without danger to the health of workers in perfumery works (see article "Perfumes").

Generally speaking, it may be said that odours are not merely a nuisance, but also a cause of ill-health. According to some experts, fetid smells, by rousing disgust, may cause loss of appetite, nausea, vomiting, headaches, weakness, and depression. On the other hand, other facts establish that smells have only a local effect on the olfactory organ without causing general symptoms of poisoning (or very rarely), and, further, that the duration of life and the state of health of the workers concerned are good and even above the average. It must, however, be admitted that, according to certain experiments on animals, there is a diminution of the resistance to infection.

In conclusion, the scientific facts which are available to-day seem to show that workers quite easily become accustomed to odoriferous substances and that smells cannot be considered as a direct cause of organic disease.

**Detection and Estimation of Odours**

While the presence of odours can be realised it is difficult to measure their intensity with the human organs of smell only. Thus, for example, the human sense of smell cannot detect the presence of a gas whose density is at least fifteen times greater than that of hydrogen. It is claimed that certain individuals can detect hydrocyanic acid (which is the limit of this density) in a dilution of two million times its weight of water. On the other hand, the famous chemist, Scheele, was overcome by this same gas, which he had discovered, and its action paralysed his sense of smell.

Experts are almost always faced with extremely serious difficulties if they wish to evaluate complaints made by the public against evil-smelling emanations.

Present-day chemical processes do not allow accurate estimation of odours. Most of them which are capable of acting on the nervous system cannot be weighed in a balance; others cannot be analysed chemically because their composition is not known.

The quantities of odoriferous particles in the air are very often so minute as-
to make errors of calculation inevitable. On the other hand, the reactions suggested for detecting certain substances (for example, acroleine) are very difficult.

Nevertheless, if the chemical composition of an odorous gas is known, the concentration of its molecules can be measured by purely chemical methods.

The idea of estimating odours is not new; it dates from 1787 when the Society of Medicine of Paris brought up the question at their meeting. However, it was only carried out much later by Gérardin, who discovered a method based on the action of odours on permanganate of potash. Gérardin gave the term “ozometric degree” to the weight in milligrams of crystallised oxalic acid, which produces on potassium permanganate the same effect as the organic matter contained in 1 gr. of air (smells, microbes, grains of pollen or dust) measured by purely chemical methods.

It is possible also to estimate odours by physical methods. As a matter of fact the idea of measuring the intensity of the stimulation of the olfactory sense. Some are in favour of a chemical action, others in favour of a physical effect, and others again favour a combined effect.

Watson denies that smell is a chemical phenomenon, for he has found that there does not exist a chemical reaction between several typical odorous substances, such as acetate of ethyl, pyridine and citronella on the one part and a substance of the proteid type, such as white of egg, on the other. Zwaardenmaker, who is similarly in favour of the physical theory, has shown that in vapourising pure water an electric charge is not formed. It is the same with water containing certain inorganic salts. On the other hand, with water containing certain organic salts vapourising produces a negative charge. When water containing dissolved odours is vapourised a positive current is obtained. Further, it has been found that the point of dilution, which allows the perception of electrical phenomena, corresponds exactly to the point of dilution at which the odour becomes perceptible to the sense of smell. Thus the electric charge constitutes an objective standard for the measure of the intensity of odours.

HYGIENE

The methods which are recommended for eliminating odours are very numerous and clearly must vary according to the nature of the industry, that is to say, with the cause and intensity of the smell. The most important methods are as follows:

1. Removal of business premises from inhabited centres and isolation of factories. This measure should be applied chiefly to premises where animal material is dealt with and all other odorous materials which cannot be completely eliminated. Unfortunately it is very difficult to keep factories indefinitely at a distance from dwellings, owing to the presence of houses for the personnel near the factories and of shops. Health regulations enumerate the trades — designated as “offensive trades” — which are subject to this measure.

2. Planting screens of trees. Two or three rows of trees (12 to 20 m. broad), planted parallel to the walls of the factory, will have the effect of preventing odours from spreading by the action of winds, or will at any rate diminish the intensity of the smell. This screen should be arranged according to the direction of the prevailing winds in the locality.

3. The use of high chimneys. By passing odorous emanations into a high chimney, they are carried into the air, where they are diluted. This measure, which is effective in reducing the intensity of smells, has, however, the inconvenience of carrying them to a distance and so causing a nuisance to the neighbourhood. For heavy odorous gases it is best to have low chimneys.

In order to get rid of the gases effectively, it is necessary to burn them, either in generating furnaces or in special furnaces which ensure complete combustion and pyrogenetic denaturation of the volatile products. It may happen, however, that these furnaces do not effect complete combustion, as only apparatus specially constructed for combustion can effect it. Furnaces are required to be of brick or fireclay heated to redness or simply elongated furnaces in which coke or coal are burned.

4. Condensation of odours. Before discharge into a chimney, odours ought to be subjected to a preliminary treatment which renders them inoffensive. The odours should be condensed in water by means of aspiration and well devised ventilation. The most satisfactory results are obtained by adding a disinfectant, such as chloride of lime, to the water which is used for condensing the odours.

5. Absorption of odours by soil. By means of his process of estimating
odours, Gérardin was able to establish the fact that soil possesses the property of absorbing odours. According to this expert, one ought first and foremost to choose soil for catching and destroying odours. As a matter of fact, soil is an agent which fulfils the requirements of both efficiency and economy.

There takes place a biological process similar to that which is associated with the purification of waste waters distributed over fields (see article "Industrial Waste Waters"). Volatile odoriferous substances are decomposed by bacteria, which destroy them by transforming the organic matter into its mineral elements. Thus it is sufficient to pass odorous gases by means of a special apparatus through a layer of soil of medium thickness.

Noxious odours produced by some trades can be suppressed by using activated charcoal as an absorbent, placed in a kind of tower into which the gas is sent for purifying. When it is necessary to revive the charcoal, it is heated in situ by the use of steam or other means. The charcoal which gives the best results is that obtained from coconut shell. This material is found to possess great absorbing power, retaining organic and odoriferous substances rather than steam; it resists crushing well, and is very active in reduced bulk. (Ray and Chaney, 1923.)

(6) Deodorisers. Odours may be weakened by appropriate deodorisers. It is, however, necessary that they be chosen judiciously, for, if not, the new odour may be more disagreeable than that which it is intended to overcome. Among these substances, the most efficient are chloride of lime and formaldehyde.

Bordas and other experts have studied the question of deodorising air by ozone. Ozonised air has an effective action on oxidisable odours. The experiments of Bordas show that most of the odours which arise from the fermentation of organic materials are entirely suppressed by ozone. This action is stronger when ozone is used in a moist atmosphere and in a magnetic field. Troubles caused by ozone, such as irritation of the mucous membranes, are easily removed by passing the purified air while strongly ozonised into a tube containing pieces of india-rubber by which the ozone is completely destroyed.

A process for the suppression of industrial odours invented by Yandell Henderson and Howard W. Haggard (1922) is widely applied in the United States and in Canada, and gives very good results. It is based on the principle of having a single outlet for the atmosphere of any factory, through one pipe or chimney only. The total emanations thus withdrawn are thoroughly mixed with chlorine and directed into the chimney in an accurately titrated amount. Should the emanation contain dust it is arrested by a scrubber (consisting of a thin water jet) prior to the action of the chlorine. Should the fumes not contain a sufficient proportion of humidity, steam is added. Deodorisation appears to be most effective at a fairly moderate temperature. It has been found that a half to 1 kg. of liquid chlorine vaporised per hour suffices to deodorise factories treating considerable quantities of material. The regulating apparatus for the chlorine is similar to that used in chlorinating town water supplies.

Taking for granted that the great majority of noxious odours arise in trades in which organic materials are manipulated, it is necessary to inquire what special hygienic measures should be applied to these businesses with a view to preventing the occurrence of odours.

Raw materials, as well as every fermentable product from which disagreeable odours can arise, should be warehoused and manipulated in the most remote parts of the factory.

Materials should arrive at the factory in the best possible condition and as fresh as possible, and should be so warehoused as not to diffuse odours. Transport should be effected in closed wagons or receptacles and unloading should be strictly controlled.

Warehouses and working premises must be constructed of impermeable materials, such as marble, flagstones, earthenware tiles, and impermeable facings; all soft porous materials and wood must be excluded. All exposed wood must be limewashed. The ground must be impermeable and must slope and have channels to help the escape of liquid residues and water used for washing down. When the floor is soiled with bad-smelling organic residue, it is desirable to scatter sawdust or some other absorbent material on the ground.

Thorough ventilation of the work-places is required, as well as the most careful cleanliness, and frequent washing, if necessary with disinfecting solutions.

Industrial operations should be carried on in apparatus which is sealed or otherwise hermetically closed with efficient exhaust draught and condensation of vapour. No use should be made, for the disintegration of materials and organic tissues, especially of animal origin, of processes based on fer-
mentation or on chemical reactions which give rise to offensive smells.

The use should be prohibited, as fuel of debris from packing, remains of raw materials of a fatty nature, or tarry and resinous, which give off in burning, troublesome and irritating odours.

Residues should be removed as quickly as possible and the places disinfected after each removal.

The accumulation in workplaces of quantities of raw materials above those infected after each removal.

All materials should be transported and kept in closed receptacles, which should be enamelled or tarred and kept in good condition, washed and, when necessary, disinfected every day at the end of the day's work.

If these measures cannot be applied, raw materials stored in workplaces should be mixed with disinfecting and deodorising substances, or covered by absorbent materials.

As regards waste waters, see article "Industrial Waste Waters".

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Opium


The condensed juice obtained by making an incision in the still unripe capsule of the poppy (Papaver somniferum) gives opium, different varieties of which are distinguished in accordance with their country of origin, or the variety of poppy from which they have been prepared (Asia Minor, Bulgaria, China, India, Japan, Persia). Opium generally takes the form of a light brown coloured mass darkening on exposure to air, with a special smell and a bitter taste. This mass contains small agglutinated seeds (larmes) of chestnut colour as well as minute greyish striated and flaked material. The small seeds or "larmes" represent the coagulated and dried milk of the poppy; the striated and flaked material comes from the detritus of the outer cover of the fruit and leaves.

Opium partly soluble in water, to which it yields about 60 per cent. of its weight, and likewise in alcohol, has a fairly complex chemical composition: resinous substances; salts; peptic, albuminoid and mineral substances; lactic, malic and other acids; numerous alkaloids which may be classed with the morphine and papaverine groups.

Opium and morphia may, though very rarely, exert an injurious action on the skin of workers engaged in their manipulation. Low reports that in the Edinburgh alkaloid factories it has been fairly frequently noted that certain workers are attacked by exanthematos affections several weeks after commencing work, whilst others retain freedom from these even after periods of twenty years. These troubles were at first attributed to strong acids in which the plants undergo maceration prior to their manipulation. Low has proved the dermatitis in question to be due to opium. By rubbing the skin of a worker who had suffered from morphine dermatitis with crude opium he obtained rapid reaction of the skin.

In a case of very extensive dermatitis which had healed, Low obtained, after rubbing for six hours with opium, very violent local reactions and in twenty-four hours a localised dermatitis on the previously attacked parts of the skin. According to his experiments, the opium alkaloid possessing the strongest action was codeine.

There have likewise been reported cases of eruption due to morphia (Bridge, Egli and Rüst).

Amongst the most carefully studied cases is that described by Lewin affecting a worker sixty-one years of age, who had been employed in the same factory for thirty-four years and on manipulation of apomorphine for twenty-five years. After transference to a morphia factory, this worker, after a few days' work, suffered from shivering fits and from a state of general excitement with fever and discomfort accompanied by a crusty eruption localised chiefly on the upper part of the body. The eruption disappeared at the end of a few days on quitting work and reappeared immediately on resumption of work. The factory doctor ascribed the eczema observed to the action of a warm solution of morphia which the worker was obliged to filter through a cloth, during which operation he came in contact with hydrochloride, acid, charcoal and lime. There occurred reappearance of the eruption, which broke out after a lapse of eight weeks from the first eruption, no longer yielded to treatment and resulted in the death of the patient. Lewin attributed the injury in this case to the fact that the acid employed had acted as a vehicle for the alkaloid, the solution penetrating into the layers of the skin which was somewhat swollen by immer-
Osmium

French and German: Osmium. — Italian and Spanish: Osmito.

Osmium is a rare metal (symbol Os) belonging to the platinum group, associated with the latter in its natural state, and likewise with iridium in the various platiniferous ores of Colombia, the Ural Mountains, Tasmania, Borneo, etc.

Osmium is extracted from insoluble residues resulting from the treatment by aqua regia of the above-mentioned ores, melted with zinc, which has the effect of concentrating the rare metals which they contain. The molten metallic mass is treated with barium peroxide, and the whole mass is thereafter washed in water; then the residues containing osmium and iridium finely powdered are treated with steam and aqua regia. The osmium is volatilised in the form of tetraoxide, which is then transformed into sulphur, calcination of which gives metallic osmium.

In the pure state it is a bluish white metal, with a metallic lustre, which melts at 2,700-2,900° C. Heated to 400° C. it burns by becoming transformed into tetraoxide. Tetraoxide of osmium or osmic acid is prepared by oxidising osmium finely divided by aqua regia and fuming nitric acid. It takes the form of yellowish crystals, with a nauseous smell, recalling that of chloride of sulphur, and with a bitter and burning taste. It melts at 40° C., giving an oily liquid boiling below 100° C. and giving off fumes at an ordinary temperature which irritate the eyes and the nasal mucous membrane.

Osmium was one of the first metals used in making the metallic filament of incandescent electric lamps.

At present it is replaced by tungsten. It is also used as a catalyst, in the preparation of synthetic ammonia, for measuring the rapidity of explosion of gun-cotton, in the manufacture of platinum alloys (scientific apparatus), with iridium (gold pen-nibs for fountain pens, tipping engraving tools for designing on glass), etc.

Osmic acid is used for activating solutions of chlorate of potassium; in work in histological laboratories, for fixing, hardening and colouring of certain preparations, etc.

Vulpian and Reymond as far back as 1874 drew attention to the occurrence of pains in the eyes and eczema on the hands among workers engaged in separating osmium from mixtures of iridium and platinum. The use of osmium cements (aqueous mixture of osmium and osmium chloride) in the construction of electric lamps, for fixing the filament on transmission wires has often caused irritation of the skin, as a result of contact with the chloride. The use of this product has now been abandoned.

Osmic acid likewise produces injuries. Deville suffered from serious derangement of sight in course of its preparation, in consequence of the deposition of small particles on the cornea.

In histological laboratories in which attempts have been made to regenerate reduced osmic acid by means of peroxide of hydrogen, splashes of the product have often caused lesions of the skin and the mucous membranes. Winkler noted, in the case of a doctor engaged on this operation, dermatitis of the hands which lasted several weeks.

Types of cutaneous necrosis met with as a sequel to the therapeutic injection of salts of osmium in the treatment of obstinate neuralgia provide adequate illustration of the caustic properties of the product.

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Oxalic Acid


Oxalic acid, of which the formula is CO₂.HC₂O₂.H and the specific gravity 1.64, is found in the form of oxalate in a great number of plants (common sorrel, wood sorrel, etc.). It is often formed in the oxidation of organic substances (sugar, wood, starch) by means of nitric acid, permanganate of potash and molten caustic potash. When crystallised, oxalic acid occurs in the form of rhomboïd crystals, odourless, colourless and transparent with a marked acid taste. It melts at 96° C. (in the anhydrous form at about 201° C.) and readily dissolves in water. It is a powerful reducing agent.

It is prepared either by the action of alkaline hydrates on cellulose at a temperature approaching 240° C., or by converting formates into oxalates (by heating a mixture of formate and calcium carbonate; the alkaline oxalate is taken up by the water and precipitated by the lime as an oxalate which is then decomposed) or by treatment of the molasses with sulphuric and nitrate acids.

Small quantities of oxalic acid are also recovered from the residual waters of certain industries (manufacture of trinitroresol).

Oxalic acid is used in tanneries to plump hides and bleach skins; in the textile industry in dyeing and printing material (dyeing of printed calico); in the chemical industry in making formic acid, glycolic acid (electrolytic reduction), for refining glycine, stearine, tartaric acid or cream of tartar; in dry cleaning (removal of rust and proteinaceous substances); in the manufacture of blue ink (dissolving Prussian blue), for certain artificial colours, in photography; etc.; in the metal industry, especially in the polishing of utensils of copper and brass; for bleaching straw, etc.

Besides its general toxic action (very rare in industry), oxalic acid has a local caustic action on the skin and mucous membranes. Elimination is very slow. Although Hayhurst has described cases of poisoning by concentrated oxalic acid among workmen engaged in polishing brass and copper articles, industrial poisoning is very rare. It can be set up by the vapour of oxalic acid and is characterised by irritation of the mucous membranes of the oesophagus, stomach and intestines. A bluish coloration of the nails has been described; these at the same time become friable. Peripheral circulatory troubles (especially of the hands), cardiac weakness, spasms, convulsions, etc., have also been noted.

Hygiene consists in preventing escape of toxic vapour during the manufacture of oxalic acid, in using closed receptacles, or, in place of them, covering the boilers with hoods connected up to efficient exhaust ventilation. The vapours and fumes should be led to the furnaces and burnt.

Legislation.—Employment of women is prohibited in Argentina, France and the Netherlands; that of lads under 16 years of age and girls of less than 18 in Canada (Quebec) and in Greece; lads of less than 15 in Italy; less than 16 in Spain, less than 18 in the Netherlands; and girls of less than 21 in Spain and Italy.

Oxalyl Chloride

Oxalyl chloride (CICOC1) is a colourless liquid which boils at 64° C. and is obtained by the action of two molecules of penta-chloride of phosphorus on one of oxalic acid. On contact with steam, fumes of oxalyl chloride give rise to oxalic acid and hydrochloric acid.

Egli and Rust refer to a case of an assistant who, in stirring potassium with oxalyl chloride in a closed metallic tube, produced such a violent explosion that the persons present in the workroom were hurled out of the window.

Oxygen


Oxygen (symbol O) is, in the pure state, an inodorous gas, with a density of 1.1053, which liquefies at —118° C. and 50 atm. (critical temperature and pressure).

Liquid oxygen has a density of 1.13, boils at —183° C., and is azure blue in colour. One litre furnishes 790, 830 and 870 litres of gaseous oxygen at 0°, 14° and 27° C., respectively. It is transported in special brass, glass or porcelain receptacles, with double walls, and a vacuum between the two (Dewar and d’Arsonval bottles).
Oxygen is an important agent of combustion. Together with hydrogen, it forms a detonating mixture. It combines likewise, with other elements, to form oxides, carbonates, nitrates, sulphates, phosphates, etc. The combustible and oxidisable substances in the atmosphere (combustible gases, explosive liquids, dusts, etc.) burn and oxidise better in the presence of oxygen and at a lower temperature than the surrounding atmosphere; they furnish besides, together with oxygen, detonating mixtures which may also be formed with certain inert substances (oils, rubber and ebonite).

On the market it is generally sold in steel cylinders under a pressure of 12, 150 or 150 kg. These cylinders are provided with stop cocks permitting of dilution.

Oxygen was formerly prepared industrially, in accordance with the methods of Thessié, Mottay and Maréchal, by utilising manganate of soda; of Mallet by utilising cuprous chloride; of Kassner by utilising plombate of calcium; of Brin by using oxide of barium.

Modern technical methods follow the lines of fractionated distillation of liquid air or electrolysis of water. In the Claude process, after purification, compressed air at 40 atm. undergoes dilution on two successive occasions, the work being effected externally. After liquefaction, the air passes into a rectification column, which furnishes liquid oxygen. In the Linde process the purified air, compressed to 210 kg., is liquefied after cooling and dilution, and flows into a separator, at the exit of which the liquid oxygen is obtained.

The Joubert process, derived from the Linde process, enables either gaseous or liquid oxygen, as desired, to be obtained from the same apparatus.

Oxygen is used alone or mixed with air; for activating forges, kilns (metal-lurgy, glass works, etc.), for obtaining high temperature flames (enamelling, tinning, metal cutting, autogenous welding; oxyhydrogen, blowpipe with hydrogen; oxyacetylene, blowpipe with acetylene); in the artificial stone industry; in the chemical industry for the regeneration of purifying mixtures from lighting gas, for ageing of alcohols, cognacs, etc.; in oxidation processes connected with bleaching and refining of fatty oils, in the preparation of ozone and acetic acid, starting with acetaldehyde, etc. When projected on to a block of quicklime and zirconium, the oxyhydrogen flame produces an extremely bright light ("Drummont light").

Liquid oxygen is principally employed as an explosive in mines. It was utilized in piercing the Simplon Tunnel. Its use was subsequently abandoned, and has only been reverted to since 1910, and more generally since 1915, in Silesia and Lorraine. The explosive consists of a fuel (liquid oxygen) and a combustion agent (mixture of various highly oxidisable substances: powdered aluminium or magnesium, soft coal, carbohydrates, hydrocarbides). Once the two substances have been brought into contact, ignition takes place by lighting a slow fuse (fuses or primers) or by the electric spark. The cartridges, according to their composition, may provide the whole series of effects obtained by ordinary explosives, and the explosions may take place under water.

Apart from its use in mines and for piercing tunnels, where it is often prepared on the spot at the moment at which it is required in special apparatus, liquid oxygen is likewise very often employed in large-scale metallurgical works for breaking pieces of iron and steel.

The sources of risk connected with the use of oxygen consist principally in the risk of explosions and accidents, and belong in consequence to the sphere of safety rather than hygiene.

It has been reported that liquid oxygen is capable of causing fairly serious burns by prolonged contact. On the other hand, some discussion exists as to whether, during its use as explosive, it liberates noxious gases. Whilst, in accordance with research effected in 1922 by the Technical Committee of the Miners' Association of Alsace-Lorraine, it has only been possible to detect in some badly ventilated development ends incalculable traces of carbon dioxide without any influence on the system, other authorities are, on the contrary, of the opinion that liquid oxygen is productive of more carbon monoxide than dynamite gelatine, unless when ignition occurs six to seven minutes after the charge. Further, it would be advisable to arrange for the lapse between successive explosions of a period of six minutes at least to be devoted to ventilation.

In pyritic mines there occurs production of sulphur dioxide which, though not nearly so poisonous as carbon monoxide, also exerts an irritant action.

Hygiene measures are restricted to provision of good ventilation.

In a factory for the production of oxygen and nitrogen, fairly serious accidents were met with, consisting in
multiple and extensive burns due to contact with the pure oxygen. Various recommendations deal with the risk of fire. The sparks produced during working on metal are liable to set oily clothing on fire. Ventilation of trenches ought to be adequate, energetic and continuous. The workers should have at their disposal facilities for rapid first-aid treatment, and should wear fireproof clothing for all work bringing them in contact with oxygen (Leclerc and Müller, 1931).

In Greece, boys under sixteen and women under eighteen, and in Italy, boys under fifteen and women under twenty-one years of age are excluded from the preparation of compressed gases, etc.

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Ozone

French: Ozone. — German: Ozon. — Italian and Spanish: Ozono.

Ozone is a condensation product of oxygen found in small quantities in atmospheric air, especially during storms accompanied by numerous electric discharges, and in peroxide of hydrogen. It is also produced: in air under the action of ultra-violet rays emanating from a mercury lamp, X-rays, etc.; during the slow oxidation of humid phosphorus in air; during electrolysis of water.

It is prepared industrially by subjecting atmospheric oxygen in a very dry and pure state to the action of electric discharges, or, what is better, electric glow discharges in special apparatus (Andreoli, Tindal-Schneller, Siemens-Halske apparatus, etc.). In all these cases there is generally obtained ozonised air which has to be liquefied and subjected to fractionated evaporation in order to give pure ozone. Pure ozone is a comparatively stable gas which decomposes slowly at an ordinary temperature and rapidly towards 400° C. Slightly soluble in water, it dissolves and combines with etheral oils, and, better still, with turpentine oil, aqueous solutions of quinine, etc. It is an oxidising and deodorisation agent, a strong microbicide, and is currently used for sterilising water and air. It is used in the preparation of heliotrope, vaniline, and artificial camphor. It is utilised for bleaching textile fibres, fatty amylaceous substances, and hydro-carbonaceous products, and as an oxidising agent for oils and spirits, etc., its action on the human system is similar to that of chlorine.

If it irritates the mucous membranes, in particular the respiratory and ocular membranes, and a dose of 0.001 grm. per litre causes perceptible irritation, whilst by a dose of 0.002 and a period of exposure lasting an hour and a half, coughing and fatigue are caused, and with a dose of 0.006 and an exposure period of one hour, coughing and somnolence. Experimentally a dose of 0.01 grm. per litre is found to kill animals by causing pulmonary haemorrhage (Lehmann). Dablez (1929) has confirmed by experiment the toxic action of ozone. A concentration exceeding 1 mg. per cubic metre of air gives rise to an irritation of the respiratory passages, diminished arterial pressure, etc. Its toxicity is, however, fairly slight in the case of human beings, since it is not "deep seated", and its forces become entirely dissipated in the first layers of tissue which the ozone encounters.

In 1932, Quarelli drew attention to the incidence of troubles produced by ozone in persons preparing or using this substance (physicians, chemists, workers, etc.). Nevertheless, from the aspect of industrial hygiene, ozone may be regarded as innocuous, the derangements noted amongst radiologists, etc., being rather attributable to certain gases liberated during the formation of ozone, notably oxides of nitrogen in laboratories where numerous electric discharges occur (Zangger).

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BIBLIOGRAPHY


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Painting Industry


The occupational dangers in the painting industry, connected with painting houses, coaches, and ships, have so many points in common that they may be studied together. They differ, however, sufficiently one from another, by the nature of the work and the materials used, to make it necessary to study the technique of these different branches separately.

TECHNOLOGY

An account of the technique adopted is only given in sufficient detail to clarify the causes and the variety of the pathological manifestations, as well as the methods of prevention, which will be described later.

House Painting

Colours used in house painting are composed of two elements: a solvent, or liquid, which acts as a vehicle, and a pigment or colour properly so called. The solvent most used is linseed oil (which may be replaced by other vegetable oils: poppy, tonka-bean, Chinese wood, etc.); it is used to soak and dissolve the pigment so as to give it certain special properties. Quite often the solvent is composed of two liquids: linseed oil, the solvent properly so called, and a volatile spirit. That most often used is spirit of turpentine, which acts as a diluent.

Although numerous cheap substitutes for turpentine exist, including various mixtures of turpentine, heavy benzene, petrol spirit, benzol, or petrol, they are little used in Europe, but "white spirit" is used considerably in the United States. Two other substances, however, obtained from naphthaline, are to-day recommended in place of turpentine, viz. tetraline and decaline.

Tetraline is naphthaleine upon which 4 atoms of hydrogen have been fixed. This substance has a density of about 0.976, boiling point about 205° C., and a flashpoint of 78° C. If 10 atoms of hydrogen are fixed on to naphthaline, decaline is obtained, in which about 20 per cent. of tetraline is always present.

White spirit is a special spirit of petrol which replaces turpentine, the price of which has considerably increased.

By refining illuminating oils, petrol which is used for illuminating is obtained (see the article "Petroleum"); various types of white spirit come from splitting up the original fractions, yielding spirits with densities varying generally from 0.760 to 0.800. White spirit is always a very irregular product, a fact which makes its density an insufficient characteristic for distinguishing it. Dangers from fire, explosion, and poisoning are especially associated with this material. In order to counteract the peculiar and disagreeable smell of white spirit, amyl acetate is sometimes added to it in small quantity, and spirit of Mirbane (nitrobenzene)—a method not much employed.

On the other hand, pigments are very numerous; the white pigments are the most important, forming usually the basis of all paints. Examples are white lead and zinc whites which have been used for many years, titanium white, antimony white and lithopone, which is a compound of zinc sulphide and barium sulphate. Attention must be directed to the fact that the science of pigments is ever turning towards composite pigments, called mixed pigments, in the composition of certain of which lithopone, for example, is an important factor. Other pigments are used only to give to the paint the desired shade by mixing them with the white pigments. The ochres are ferruginous clays of a yellow or red colour.
There are also Prussian blue and ultramarine, chrome yellow, greens (certain of which, derived from copper, are very poisonous), varnish (which is a combination of sulphur and mercury), as well as others.

Minium, a red oxide of lead, in particular is often used, as it preserves iron from rust very effectively. It is not prohibited, as white lead is, but in view of its toxicity several substitutes, such as oxide of iron, and paints with a chromate and graphite basis have been proposed which may perhaps suppress its usage entirely (see the article "Red Lead").

Besides colours properly so called the house-painting trade employs:

- varnishes, mixed or not with benzene and a drier;
- driers, added as liquids containing oil, benzine, manganese, and litharge, or in powder, e.g. salts of zinc and manganese;
- encaustics mixed with water, such as wax, white soap and salt of tartar and water, or yellow wax, American potash and water; or mixed with spirit, e.g. wax dissolved in spirit.

The silicates of potash or soda, as well as another silica salt, sold under the name of silexore, are also used, mixed with Spanish white or oxide of zinc to make special distemper, which can be applied to surfaces which are quite porous, and in particular upon new cement; it has besides a special affinity for zinc and glass.

Painting work can be divided into two chief categories: (1) preparation; (2) finishing.

(1) Preparation work.—Before any painting can be done, it is necessary for objects and surfaces which are to be painted to undergo beforehand certain preparatory operations of which the chief are dusting, smoothing, burning or scraping, washing or cleaning down, and application of the priming coat.

As regards new surfaces which are more or less soiled during the period of seasoning, or old surfaces of walls and woodwork more or less covered with dust, a kind of general cleaning (dusting) is necessary. This applies to all parts, objects and surfaces to be painted, before the operation both of preparation or of finishing. The work is carried out from the top downwards by means of a small brush. Smoothing is particularly necessary for plaster work and has for its object the removal of all particles resting on the surface to be painted. These two operations are specially necessary with new work. For maintenance work, such as on old walls plastered with mortar, thorough scraping by means of a triangular scraper must be used to remove the smallest scrap of such paper; cleaning is particularly required when old paint is sticky or is peeling off in flakes, and when coats of a lighter colour than those already on are to be applied.

The different methods of cleaning down are: with potash, by using a solvent, or by burning. It is important to emphasise that in the second method the following are used as solvents: acetone, amyl acetate, alcohol, benzene, methyl alcohol, nitrobenzene, and especially a combination of these substances. The solvent is applied either by a bristle brush or a knife, according as to whether it is liquid or a paste. There is thus danger of poisoning, explosion or fire, according to the toxicity or the inflammability of the materials used.

The process of burning is carried out by means of a burning lamp using petrol spirit, which is able to give a flame of which the temperature reaches nearly 2,000° C. Modern lamps are provided with safety valves which regulate the flame; their use generally does not present any special dangers.

After the two preliminary operations comes the priming coat, which is applied to a surface carefully dusted and rubbed down, not soiled by the least dirt or grease and perfectly dry. This coat should leave upon the surface to be painted a thin layer which will act to some extent as a foundation and will facilitate not only the success of the following coats, but also the operations of rubbing down and stopping.

The whole of the priming coat should next be rubbed down with glass-paper to remove the rough particles of paint, so as to make a foundation as trim as desired, and to allow the colours to lie even. Then follows the process of stopping, which is very important in painting; it consists in filling holes and removing splinters and flaws.

(2) Finishing work.—When the preparatory work has been finished, the stopping quite dry, and the mastic set hard (for which time must be allowed), the finishing work is proceeded with, that is to say, the application of coats of paint and the operations which that entails. The products used vary according as to whether the work concerns woodwork,
metal surfaces, walls or ceilings; and further as to whether these surfaces are interior or exterior, that is to say, more or less exposed to deteriorating influences and to bad weather conditions.

Work upon walls as well as woodwork is finished with lacquered or enamel paint; most of those which are used at the present time in the trade have as their base zinc white and special oils of linseed (Europe) or fish oil (America). These paints contain also variable proportions of white varnish called "crystal varnish".

Outside walls and woodwork receive a priming coat and can then be washed down with silicate.

Outside ironwork is treated thoroughly with the hammer, knife and glass-paper; a coat of red lead or oxide of iron is then applied directly to the iron. This question of the protection of iron against rust is specially important as regards shipbuilding (see later).

Finally, coats of paint are applied, which vary according to the tone required, and then varnish.

Walls of interior courtyards may be whitewashed with lime with the double object of providing light for rooms which face them and giving the walls a clean appearance.

Generally speaking, it should be noted that, according to the opinion of most experts, white pigments are the only ones that can be actually employed with every reliance from the point of view of complete protection. Other paints generally, even the ochres, present a surface out of doors which is not comparable to that given by the two whites, and only lasts in proportion to the amount of white in the mixture.

Painting of Boats and Ships

A technical account of the painting of vessels intended to act as a means of transport upon water is difficult for several reasons.

First comes the multiplicity of types according to dimensions and uses; then the variety of materials of which they are constructed; then the necessity of using different processes according as to whether protection is being given to submerged parts or ships' bottoms.

Exposed to the action of water, seaweed and shell-fish, or, on the other hand, to upper works which escape such exposure.

Preparation and painting of new surfaces. — Wooden vessels should be considered first because they are the oldest, and are still at the present time most used for carrying light tonnage. Besides, "though it may be said that wooden ships practically disappeared before the war from maritime commerce, circumstances have so enhanced the cost of sheet steel, indispensable in the construction of modern steamboats, that certain Governments, the chief suppliers of commercial tonnage, have ordered the construction of a number of wooden ships of large tonnage, hundreds of which have been constructed and are at present ploughing every ocean " (H. Craen).

For covering wood with a priming coat to protect it against rot; this priming coat is put on in a different manner depending on whether it concerns the ship's bottom, the superstructure or the interior of the hull.

The simplest method of protecting the wooden bottoms of fishing vessels, trawlers, etc., consists in the direct application upon the wood either of pitch kept at boiling point by the aid of braziers close to the worker, or of vegetable varnish, called Norwegian pitch, applied cold.

For vessels of greater tonnage — merchant ships, pleasure boats, etc. — the wooden bottoms are generally treated as described in the following paragraph.

First comes puttying, if required, using a base of linseed oil and white lead or zinc white, particularly using zinc white made by the direct method, with the object of filling all the cracks and crevices; this is followed by rubbing down with pumice stone, either dry or with water, in order to ensure an absolutely smooth surface. One or several coats of lead paint, using red or white lead, are then applied; this application may be made immediately without preliminary puttying. It should be borne in mind that workmen using putty have the habit of working it frequently in their hands in order to keep it supple, and from this there is danger of poisoning if the putty is made with white lead.

When once these coats have been applied it is necessary to take into account the fouling of the hull by seaweed and shell fish, which tend to develop there until they constitute a thick covering. The severity of the fouling varies much according to diverse factors: the kind of water, e.g. that of ports is full of diverse factors: the kind of water, e.g. that of ports is full of
resistance of the surface, which from being smooth becomes rough and so hampers progress; on the other hand, it forever lays little by little the oily material which has acted as the vehicle of the paint, which then becomes friable and comes off on friction.

Clearly then a fight must continually be waged against fouling. The sheathing of wooden bottoms with a covering of copper, commonly used formerly, was a very efficient means of protection. The copper on coming into contact with sea water becomes transformed little by little into chloride and carbonate of copper which drops off carrying away the growths which have fixed upon it. This sheathing has, besides, the advantage of protecting the wooden hull against attack by certain organisms and particularly by the shipworm or teredo, a lamellibranch sea mollusc, which perforates the wood of piles and ships not protected against it.

There is to-day a tendency to increase the use of special coats, or different compositions, containing poisonous salts of arsenic, copper or mercury, which preserve the wood against shipworms and other parasitic organisms, and also volatile solvents, such as benzol, benzene and xylol, the presence of which causes the coat to dry rapidly in the air and to harden firmly in water. This dried coat exfoliates little by little carrying with it the algae and shell fish and so leaves the hull clean.

Among the numerous products employed against fouling we may mention "Schweinfurt green" made into a paste with benzene, the "Antifouling" colours, "Copper antifouling paint", "Algicide", "Anti fouling composition", etc.

Moreover, as regards wooden hulls made of valuable kinds of timber, they are sometimes, without any painting, simply sanded, rubbed down and varnished (see the article "Poisonous Woods").

The upper works of wooden ships (the holds) are often covered with limewash which effectually prevents the development of organic germs. The limewash is prepared by diluting slaked lime with water; gelatine added to the milk of lime improves the adhering quality of the wash, which however does not hold sufficiently. Similarly pitch is used, or bitumastic derived from pitch and bitumen; it is used hot, and, like pitch, gives off a decided smell of creosote.

As for the cabins they are either varnished, or painted with white lead, or zinc.

In steel shipbuilding the first and most important question which presents itself is that of protection against corrosion by the formation of rust.

It is known that rust, ferric hydrate, is a friable and porous substance, produced by the oxidation of metallic iron by the action of atmospheric air or of air dissolved in water. The deterioration at first goes on very slowly; but as soon as the first touch of rust is found, the iron oxide being electro-negative in relation to the iron, oxidation is accelerated.

Steel, which is of complex composition, placed under the same conditions as iron becomes oxidised much more rapidly. When steel first came into use it lacked homogeneity and its oxidation proceeded rapidly; to-day its corrosion is slower. Mechanical changes assist defects in permanent homogeneity by favouring oxidation.

In addition two other matters have to be considered: protection against fouling, and means for avoiding troubles proceeding from the conductivity of steel plates as regards cold, heat and noise.

All corrosion could be prevented if a coat could be obtained perfectly adherent and impermeable to air and water. In practice this result is impossible to obtain. On the one hand, external mechanical causes cannot be avoided, such as shocks and friction, which partially remove the protective coating. On the other, constant exposure to water, as regards the hull below the water line, and exposure to storms, as regards part of the upper works, result in a disastrous infiltration of water, at some points penetrating the protecting paint. Then atmospheric oxidation are formed with the setting free of hydrogen, which pushes up the paint and forms blisters — openings which facilitate further infiltration of water.

But if this corrosion cannot be totally avoided, it can be at least partially avoided by two courses: first, preliminary protection, as complete as possible, of all defects in homogeneity; then application of a protective coating.

When construction work is carried out quickly and the preliminary exposure to the air is of short duration, mechanical scraping must be more thorough. This must also be done for certain metal hulls of particularly fine build. This is done either by brushing with a metal brush, or by rubbing with pads of tow dipped in sea water full of slime and sand, which is removed after two days, or by cleaning with a sand blast; this last process has
PAINTING INDUSTRY

For the superstructures, cabins and living quarters the cleaning of paint and varnish calls for the most perfect technique, sometimes pumice stone is employed, sometimes scraping combined with the burning lamp, sometimes rapid rubbing down with a solvent or a lessive (see above).

Double bottoms, tanks, and store-rooms require to be emptied before painting repairs are undertaken, for they contain accumulations of bilge water, bodies of rodents, and other things, the fermentation of which causes the production of noxious gases, such as carbonic acid and sulphur dioxide.

When once these places have been cleaned out, paints preserving coats are applied similar to those used when the surfaces were originally new.

**Coach Painting**

The ordinary work of freshly painting carriage work, or of renewing the paint, is generally based upon the same principles described above when describing the painting of wood or metals. But when high-class work is concerned, as, for example, the bodies of motor-cars, the technique is very complex. Following is a list showing the different categories of workers employed.

1 Preparers deal with the coach on its passing from the hands of the carpenter. They apply the priming coats, called preparatory coats.

After a preliminary cleansing with spirit of turpentine, eight coats are put on successively. The first is a coat of linseed oil and varnish (wood filling) and does not contain any elements of lead. It has the drawback of drying slowly and is not used if time presses.

White lead or zinc white is used for these coats. When the first coat is absolutely dry, it is rubbed over with very fine glass-paper and a second coat of a greyish tinge is applied. After thorough drying, preparation coats are next proceeded with. Seven or eight preparation coats may be replaced by three or four protective coatings applied with a knife which is broad, short, and rigid. All roughness is completely removed by rubbing with pumice stone. According to an enquiry by Hein and Agasse-Lafont the preparers are the men most exposed to risk of poisoning.

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The categories of workers in Great Britain are not in every case the same as in France. Hence the names used in the text must be considered as translations rather than as technical terms used in the coach-painting industry.
(2) **Painters** or **foundation men** do the putty work and dressing down, and then apply coats of paint. The colours are ground in spirit.

**Mixers** and **apprentice painters** help in the preparation of the colours and the paint. Throughout the large majority of works, coach painters receive almost all their materials ready for use so that these workmen are not principally employed in grinding the materials as in days gone by.

The painters’ labourers, who do the rough work, the skilled painters, filet painters, the touchers-up and the letter writers, like the foundation men, all do work which necessitates the use of colours ground in spirit.

(3) **Finishers** put on the varnish.

(4) Rubbers down pass pumice stone over the coats of paint to smooth their surface. Rubbing down is done with pumice stone and water, the object of the moisture being to prevent the generation of dust containing lead. It is considered that they are not exposed to much risk. We shall see what weight can be attached to this opinion.

(5) **Polishers** have a similar rôle with regard to varnish, which does not contain lead compounds. The polishing of varnish is done with pumice stone powder and water, the moisture preventing the formation of dust, which is, nevertheless, considered almost harmless in itself.

It is obvious that, though, taken as a whole, all these workers are exposed to lead poisoning, their exposure arises from the conditions of work, and undoubtedly varies in degree.

In addition to applying paint with a brush, which is the most usual method, two other very important methods of painting have to-day to be considered: pneumatic painting (aerostyle) by means of spraying machines, used particularly for the painting of large surfaces or a succession of small articles; and painting by dipping, a rapid, final and complete process suitable for dealing with a large series of articles.

There is no need for a compressed-air installation to work painting machines; it is now possible to use cylinders of compressed air or of nitrogen or carbonic acid. The first atomisers were used for projecting colours mixed with water or for limewashing. Walls should always be carefully dusted down and scraped. The application of paint by an atomiser has advantages: rapidity of execution, economy of manual labour, the possibility of reaching surfaces difficult of access, very slight wear and tear of apparatus, a short apprenticeship for the workers, and perfect uniformity of the paint. But it also has serious disadvantages. Injuries due to the inhalation of diluting agents and volatile solvents utilised in cellulose paint are dealt with in detail below. Besides the waste which the formation of vapour entails, in the long run it renders work very difficult for the operator, who moves in a veritable atmosphere of paint, and if the preparation used has a lead basis, such as white lead or red lead, the danger is very great (see below). It is necessary therefore to provide a thorough system of ventilation by which the particles of paint in the air are rapidly removed and even to install hoods with localised exhaust draught — which, indeed, has been done already. The absolute solution of the problem would clearly be to use non-poisonous paint.

Middleton (1930) found that in samples taken at the level of the workers’ mouth during spray painting with products with or without lead content, but diluted with water, the particles of mineral substance attained the figure of 2800 cubic cm. of air; 90 per cent. of these particles were under 2 μ in diameter. When water is the medium there occurs dispersion of the solid substances many of which are sufficiently small to reach the lungs. Risk is therefore in proportion to the composition of these solid substances.

On the other hand, with an oil medium the solid particles remain in the vapourised droplets varying in diameter from 2-15 μ whilst each droplet contains numerous solid particles. The number of droplets is about 60 per cubic cm. The difference between the kinds of vapour produced is dependent on regulation of the air and paint supplied to the spraying apparatus. Technically speaking, it is not at all essential to have a visible mist. A young worker who during one month had applied by spray without localised ventilation paint containing 52 per cent. of soluble lead showed in early but distinct haematological symptoms. Middleton met with similar symptoms in another worker who had several weeks previously left his occupation, in which he had been engaged for six months for alternating weeks.

But there are other sources of poisoning which must be considered: solvents, especially those which dry rapidly, such as benzine, etc.; and more particularly submarine protecting coats, “anti-fouling” paints which,
to fulfil their purposes, must contain compounds notoriously poisonous, such as oxide, chloride, sulphate, arsenite or arseniate of lead; sulphocyanide or ferrocyanide of copper; yellow oxide or dichloride of mercury. From the technical point of view there are disadvantages connected with it: waste of paint, lack of adherence of the coating applied, difficulty in obtaining coats of uniform thickness, and blocking up of the tubes of the apparatus.

But we must acknowledge that the painting machine is being improved day by day and that most of these disadvantages can be modified or abolished.

This method is largely used in the application of cellulose paints which includes the following operations. After the metallic surface has been cleansed with alcohol and phosphoric acid, puttying and smoothing by hand follow. Then the foundation or preparation coat is put on, followed by a second foundation coat. Wet rubbing down with pumice stone and one or several coats of cellulose paint follow, and then, after drying, comes the finishing coat of enamel.

Varnish is a solution of nitrocellulose in a mixture of amyl alcohol, amyl acetate and acetone.

Where the surrounding temperature is moderate and the benzene content of the paint does not exceed 15 per cent., the risk is non-existent provided the work is done under an effective system of local ventilation. There is a growing tendency to substitute xylene or toluene for benzene.

In her enquiry, Dr. Overton (1930) studied the application (in winter) of cellulose varnishes used under a localised system of ventilation. The paint contained 30-40 per cent. of toluene and 60 per cent. of xylene with impurities consisting of traces of benzene. She found three parts of toluene and xylene per 10,000 parts of air. She found only one case of a worker suffering from purpura.

In several countries contracts require that paints shall not contain over 5 per cent. of lead.

Various Kinds of Painting

Painting by dipping is largely employed in America in metal works and the workshops of builders and producers of chemicals and varnish, and in oil works; it only consists in the rapid application of a special enamel by immersion. The plant comprises a dipping bath, a draining table and a drying place. During the operation of dipping there stands by the side of the bath a barrel of spirit of a density of 0.720° to 0.730°, for thinning down the mixture, for replacing spirit as it evaporates, or for washing over articles that have been too thickly coated. The system of draining on "a fixed double table" compels the worker to move his position in carrying the vessels to the table by straightening himself to his full height. According to experts, experienced workmen do not complain of fatigue or pain in the back, which, on the contrary, is very prevalent with tables of other patterns, where the workman in continually obliged to bend right down to dip the vessels and deposit them before him and take up two others placed on the ground by his side.

In the drying rooms, it seems, the methods vary according to the special conditions of each case. From the health point of view, if the paints contain poisonous substances, draining upon the floor and handling done without observing special precautions may easily cause poisoning. The evaporation of spirit solvents from the baths and especially from the dipped surfaces may also vitiate the air and presents risk of fire or explosion.

Mention must also be made of the lacquering of machines, such as motors, large and small apparatus of the electrical industry, and machine tools, which includes ordinary mat paint and highly brilliant paint. The technique is always the same. The final coat consists of good varnish which resists heat. Some small articles are lacquered with colour-enamel applied by spraying or dipping; and then dried in an oven.

STATISTICS

It would be interesting to give here some statistics of sickness and mortality in the different categories of painting work. Unfortunately such a study presents great difficulties and is subject to numerous sources of error. As a matter of fact, when it is desired to make an enquiry in a workshop or a factory, only the workmen who are in full active work are seen. Nothing is known of the absentees, as to whether their absence is due to mild or serious causes. Precise information can only be obtained concerning the medical history of those present and who are therefore comparatively well at the time of the enquiry. If then few sick casualties are reported, it cannot be concluded that such casualties are exceptional. Men severely affected are necessarily eliminated from an enquiry of this sort; some only recover of actual sickness at the time; others may have definitely left the trade: some indeed may have died from industrial
disease. Thus, a blank exists which cannot be filled in without knowing the exact number of workmen employed in a factory during a fixed period of time, and determining the percentage between those present and those absent, and in the case of the latter finding out the cause of their absence, their condition at the time of the enquiry, or at least their condition when they left the trade.

The Medical Sub-Committee of the Committee on White Lead appointed by the Third International Labour Conference (Geneva, 1921) concluded, concerning painters who use white lead and other compounds of lead, that "lead poisoning is the chief occupational danger; nevertheless statistics are unreliable; as regards the death rates (a) in the first place because deaths due to lead poisoning may be excluded and appear under other headings, and (b) secondly, by reason of the inclusion under the heading of lead poisoning of deaths due to other causes; as regards sickness, statistics are unreliable due to omissions in notifications and verification and to other imperfections." The Sub-Committee formed the opinion that "compulsory notification of suspected cases of lead poisoning by medical men and verified by independent medical practitioners would not only give, as now happens in certain countries, satisfactory statistics."

Though the cases of wrongly diagnosed lead poisoning are not at all numerous (which is proved), the cases given in statistics should be considered as a minimum. But, in spite of this statement, statistics show the existence of a state of things which demands the attention of experts and legislators.

Australia, New South Wales. — During an official enquiry conducted in 1921 figures relating to painters and workmen in other industries liable to lead poisoning were collected. It was found that about 60 painters were engaged in the trade; it was considered that the figures for that year were less liable to variations in statistical accuracy due to unusual conditions and that according to these statistics the death rate was highest for painters between 50 and 54 years, whilst for carpenters taken as a standard it was between 60 and 64 years.

For painters the average age at death is 43.5, for carpenters 60.9 and for workmen in general 57.1. These figures deal with workers from 15 years old and upwards. But if the figures start with workers from 20 years old, then the following are the results: painters 54.5, carpenters 61.6, other workers 57.8.

Without entering into details one may call attention to the following passage in the report: "If the death rate of painters grouped according to age was applied to the active male population, the resulting death rate would be 15.7 per thousand (instead of 12."

The excessive mortality due to certain diseases among painters is 296 for lead poisoning, chronic nephritis (against 0.4), 152 for chronic nephritis (against 55.3) and 128 for tuberculosis (all forms) against 90.4. Hence per thousand deaths, the excess mortality attributable to the influence of lead is 150.

As regards mental diseases, the figures collected enable the conclusion to be drawn that for a thousand deaths reported each year among painters, about 1.2 are due to mental trouble following lead poisoning, whilst among other workmen of the male sex the proportion is 0.8.

Canada. — A report upon occupational risk of lead poisoning from the use of paint by spraying was presented in 1922 by the Institute of Pharmacology of Toronto. According to the author, makers of such sprayers certainly realise the danger which arises from the use of their apparatus and recommend in its use the adoption of protective measures, such as the wearing of masks and helmets.

The enquiry showed that thirty firms in Toronto, and perhaps more, each employed one to three sprayers either for the interiors or for exterior work. The enquiry was confined to interior work where it was not possible to extract the dust and spray.

Pneumatic painting of articles of small size is carried on in workshops provided with exhaust draught and only the casual workmen use masks. In every case, except one, where paint containing 3 per cent. of lead was used, the workmen declared that as far as they knew the use of lead paint was very rare.

It was difficult to determine the exact part played by sprayers in causing a risk from lead poisoning, for workmen who do not use lead paints, or who use paints containing little lead, were nevertheless occupied on other work which might be a source of poisoning.

It was, therefore, decided to make some tests with paints containing 10%, followed by white lead prepared according to the formula required for use in sprayers. Without entering into details, it is sufficient to state that the following facts have been noted: an unmistakable mist existed at 3 metres from the operator; a mask was covered with a fine coat of paint, especially at the level of nose and mouth; the hands and arms of the operator were soiled with paint; a slight sensation of suffocation was experienced which persisted even some time after the cessation of work. Investigations into means of protection, carried out in a workshop where small articles were being painted, wherein a kind of cabinet was used, furnished with excellent extracting arrangements and an opening for the introduction of the article to be painted, proved that the workman did not experience any difficulty in breathing and that he had no traces of paint either on his clothes or face. Only his arms and hands, introduced into the cabinet for handling the articles were soiled with paint.

In the course of tests for spraying interiors, the investigator found from 135
to 417 mg. of lead per 10 cubic metres, which means that under these conditions a workman during 8 hours might inhale 60 to 180 mg. of lead per day.

In another test lasting three days the urine of a painter, who had worked in the interior of a building for four or five hours a day, was analysed. The urine was found to contain 0.3 mg. of lead and the lead was less than 2 mg. The presence of lead in the urine after so short an exposure is very significant.

The enquiry also dealt with various types of masks which are used to protect workmen. Experience showed that a type of mask of gauze, cotton wool and animal charcoal could not be tolerated by any worker; and further that the animal charcoal did not arrest the lead. Any mask becomes unfit for use when it is covered with a coat of paint. Experience shows that a really efficient mask could not be worn without causing the workman inconvenience, and also it was established that in the use of a sprayer for applying paint with a lead basis to the interior of a building, there is always a danger of absorption of poison.

In painting small articles, danger of lead poisoning is considerably reduced by using cabinets supplied with an efficient exhaust draught. These cabinets sometimes have defects which must be carefully looked for and eliminated. Further, the worker in this case more than any other is exposed to poisoning by the volatile contents of the paint. An enquiry upon this point is about to be organised.

France. — Cases of lead poisoning notified under the Compensation for Industrial Diseases Act (1919) from 1921 to 1928 reached the figure of 8,628, of which 391 occurred in the painting industry. It is important to note that the cases of lead poisoning amongst painters numbered 13 out of a total for all industries of 141 in 1921, 64 out of 797 in 1922, 76 out of 1,025 in 1923 and that they were only 42 out of 1,040 in 1927, 43 out of 1,525 in 1928, 37 out of 1,848 in 1929 and 36 out of 1,652 in 1930. The 1921 census shows a total of 25,535 painters. The total for 1926 is 47,000 in round figures.

By way of example the results of an enquiry recently made by Heim, Agasse-Laurent and Feil, of Paris, among a group of 88 coach painters, represent by no means a selection, but almost the total number of workmen employed in two factories doing work exposing them to poisoning; as a matter of fact the men temporarily absent and those who objected to examination were very few (about one-fifth). It is then legitimate to consider that the results obtained represent an average and can be generalised.

These workers, for the most part men (77 out of 83), were of very variable ages, from 13 to 72 years; they carried on their trade of painting during a similarly very variable length of time, from 3 months to 50 years. In connection with this last point it is important to bear in mind that two-thirds, 53 out of 83, had worked in the lead trades for more than 5 years.

As to the nature of their work, it can be divided into two groups:

(a) Preparers, painters or foundation men, mixers and apprentice painters, layers-on of paint, skilfed painters (filet painters), touchers-up, letter painters and finishers, who directly handle injurious substances.

(b) Other workmen employed in perfecting by smoothing with pumice stone the coats of paint and varnish.

The blue line on the gums was present, very clear in 25 per cent. of cases and slight in 40 per cent.; a total of 62 per cent. positive.

The presence in the blood of red corpuscles with punctate basophilia was found in 56 per cent. of cases.

As regards the other blood changes, the presence has been noticed; almost constantly of red corpuscles with a basophilic protoplasm and a tendency quite marked to mononucleosis (44 per cent. of cases). This is of much less importance than the preceding.

Further, search for lead in the urine, which is very important from the point of view of diagnosis, as well as regards the pathogenesis of renal conditions, could only be made on 16 workmen who were taken by chance and not selected. The result was positive in the proportion of 81 per cent. of cases.

The preceding signs when they exist alone are typical of latent plumbism or a pre-poisonous stage.

As regards actual morbid conditions of lead poisoning, that is to say, of confirmed lead poisoning, among the workmen examined by Heim, Agasse-Laurent and Feil, two morbid manifestations have been met with, i.e. lead colic (6 per cent.), and hyper-arterial tension (27 per cent.) — concerning which, however, it is very often difficult to estimate how far the pathological features may be due to lead poisoning alone or to other common causes of renal sclerosis.

On the other hand, if, as a starting point, the presence of lead in the urine is taken, all the characteristic signs and all the lesions reported among the men examined, i.e. blood corpuscles with punctate basophilia, mononucleosis, blue line, hyper-arterial tension and lead colic, are found proportionately more frequently among those men who have lead in the urine than those who have not.

As regards the age of the workmen, it is interesting to note the comparative rarity of mononucleosis in the case of old men, which is doubtless due to a diminution of the activity of their blood-making organs and of their vascular endothelium; and, by way of contrast, the frequency among them of hyper-arterial tension.

The study of the period of active work in the trade, which may be comparatively independent of the question of age, shows that the presence of lead in the urine and mononucleosis are frequently early signs, as also is lead colic. On the contrary,
the blue line and the presence of cor-

puleses with punctate basophilic increase

mordecialy with the length of expo-

sure.

As regards the nature of the work, Heim, Agasse-Lafont and Feil have re-
ported not only the painters and polish-
ers, who do not directly handle sub-
stances containing lead and work with

moisture to avoid the inhalation of dust, 

would appear, a priori, from this fact to

be less exposed than others; in reality 

they are more exposed. Without being 

able to make allowance for considera-

tions of age or for length of employment 

at the trade, they exhibit as high a per-

centage as do preparers and painters as 

regards blue line, granular red cor-

puscles, mononucleosis, and definitely higher as 

regards lead in the urine and hyper-

arterial tension.

Germany. — A very detailed enquiry is 

that of Kneisch relating to Bavarian paint-

ers, which, however, deals with the years 

1910-1911. It concerns about 3,000 work-

men, most of them between twenty and 

forty years; 8 per cent. only were more than 

50 years. About 13.8 per cent. showed 

signs of lead poisoning; about one-third 

had one or more acute attacks. Eighty-five per cent. of the workers under 

consideration suffered from colic and 3.5 

per cent. from paralysis. Although among 

these workers in no case of cerebral trouble 

had occurred, an enquiry made in the 

hospitals of Munich brought out that 

there were several cases of encephalop-

athy. About 29 per cent. of workmen 

examined showed either objective or sub-

jective symptoms of lead poisoning; a 

blue line on the gum in 11.8 per cent.; 

anaemia in 6.5; and also troubles of the 

digestion, the circulation, and the kidneys.

According to the statistics of the Leip-

zig Sick Fund (1910), the frequency of 
sickness among 100 painters, lacquer-

ers, and varnishers (that for 100 insured 

workers is shown in brackets) is given in 
definite figures as follows: cases of 
sickness, 43 (40); deaths, 0.72 (0.77); 

days of sickness, 1,017 (855); infections, 

156 (142), of which pulmonary tubercu-

losis, 76 (62); poisoning, 178 (0); diseases of the 
nervous system, 52 (46); respiratory dis-

cases, 146 (149); circulatory, 34 (31); 
digestive organs, 104 (92); diseases of the 

skin, 50 (58); of locomotion, 59 (78); neg-

tional injuries, 117 (170); accidents, 61 

(94).

The statistics of the Chemnitz Sick 

Fund for 1936 of "workers engaged on 

constructional work", including painters, 

provide data regarding incapacity for 

4,190 workers. Cases of sickness during 

1926 reached 4,695, of which 583 affected 

members under twenty years of age. 1,897 

for those aged twenty-one to thirty years; 

870 for those aged thirty-one to forty years 

of age; 633 for those between forty-one 

and fifty. Deaths reached a total of 37.

Those diseases showing a high rate are 

the following: respiratory diseases, 556 
cases; diseases of the digestive system 

and of the liver, 524; of the locomotor 
system, rheumatism, gout, 898; other dis-
eases of the locomotor system, 194; 
pulmonary tuberculosis, 232; poisoning 
accounts for only 6 cases. The ages most 

affected are in general those between 
twenty-one and thirty especially for res-

piratory circulatory diseases, affections of 

the locomotor system and accidents. The 

latter amounted to 1,078.

Great Britain. — From 1910 to 1921 the 
cases of lead poisoning reported in the 
painting industry as notified to the 
Factory Inspection Department were (the 
fatal cases being shown in brackets): 1,470 
(230) for painters employed on buildings 
(for which branch of the industry notifi-
ication is voluntary), 550 (39) for coach-
painters, 247 (27) for ships' painters, and 
366 (19) for painters in other industries. 
From January 1927 notification became 
compulsory also for painters in the build-
ing trade.

For the period from 1925 to 1930 the 
notified cases are classified as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>House painting</th>
<th>Coach painting</th>
<th>Ship building</th>
</tr>
</thead>
<tbody>
<tr>
<td>1925</td>
<td>37 (14)</td>
<td>11 (3)</td>
<td>8 (2)</td>
</tr>
<tr>
<td>1926</td>
<td>46 (21)</td>
<td>13 (4)</td>
<td>9 (1)</td>
</tr>
<tr>
<td>1927</td>
<td>42 (15)</td>
<td>20 (8)</td>
<td>12 (5)</td>
</tr>
<tr>
<td>1928</td>
<td>40 (12)</td>
<td>15 (1)</td>
<td>12 (1)</td>
</tr>
<tr>
<td>1929</td>
<td>52 (17)</td>
<td>13 (3)</td>
<td>8 (1)</td>
</tr>
<tr>
<td>1930</td>
<td>76 (5)</td>
<td>20 (4)</td>
<td>24 (2)</td>
</tr>
</tbody>
</table>

The cases occur particularly amongst 
older workers, but the restricted num-
bers make it difficult to draw any con-
clusion. Other figures for the same 
periods according to the ages of the 
painters affected are as follows:
more numerous than elsewhere, but there must be taken into consideration the numbers of those exposed to the work in question.

According to the report of the Departmental Committee on the Danger of Lead Paints of 1923, the proportion of workmen affected can be estimated approximately for some of the lead industries. Any estimate is most difficult as regards house painters. The figures given below must be accepted with all reserve. The number of painters is that given by the Committee on House-Painting as an average for the period comprised between the census of 1901 and that of 1911; the number of workmen exposed to poisoning in coach-painting is that given for the year 1912 in the report of the Committee on Coach-Painting:

**COMPARISON OF THE RATES OF FREQUENCY OF LEAD POISONING AMONG LEAD WORKERS IN CERTAIN LEAD INDUSTRIES**

<table>
<thead>
<tr>
<th>Trades</th>
<th>Approximate number of persons employed on work where lead is used</th>
<th>Number of cases</th>
<th>Number per 1,000 workers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1911</td>
<td>1912</td>
<td>1913</td>
</tr>
<tr>
<td>White lead</td>
<td>1,405</td>
<td>1,382</td>
<td>1,301</td>
</tr>
<tr>
<td>Electric accumulation</td>
<td>1,140</td>
<td>1,254</td>
<td>1,475</td>
</tr>
<tr>
<td>Pottery</td>
<td>6,710</td>
<td>6,142</td>
<td>7,080</td>
</tr>
<tr>
<td>Smelting</td>
<td>2,830</td>
<td>2,480</td>
<td>2,573</td>
</tr>
<tr>
<td>Printing</td>
<td>58,800</td>
<td>58,800</td>
<td>58,800</td>
</tr>
<tr>
<td>Coach-painting</td>
<td>29,308</td>
<td>29,308</td>
<td>29,308</td>
</tr>
<tr>
<td>House-painting (a)</td>
<td>150,000</td>
<td>150,000</td>
<td>150,000</td>
</tr>
<tr>
<td>House-painting (b)</td>
<td>150,000</td>
<td>150,000</td>
<td>150,000</td>
</tr>
</tbody>
</table>

1 For house-painting the rates have been calculated in two ways, as follows:

(a) By the aid of the number of notifications and death certificates during the year. These figures, however, do not represent the total frequency, as notification is not compulsory for house-painters.

(b) By taking for granted that the relation of deaths due to lead poisoning to cases of lead poisoning is the same among house-painters as for lead workers in factory industries. This relation is known for lead workers in factory industries, while the number of deaths due to lead poisoning among house-painters is obtained from the death certificates which the local registrars receive.

For the period 1928 to 1930 the annual average incidence for 150,000 painters appearing in the census was per thousand 0.6, 0.5, and 0.4 as contrasted with an annual average incidence of 10.3, 6.5 and 10.1 amongst lead founders: 6.4, 4.5 and 7 amongst workers in storage battery factories; and 7.7, 4.4 and 1.1 amongst white lead workers.

The statistics submitted by Dr. Legge to the Committee on Coach-Painting covering 14 years (1900-1913) give the following results: out of 219,889 persons employed in the painting industry, 29,308 were employed upon work involving the handling of compounds of lead. But the number of cases of lead poisoning in this working population has been 1,026, giving an annual average of 73 cases, of which about 6 per cent. were fatal. During this period the sickness rate for lead poisoning has been 2.50 per 1,000 and the death rate 0.149 per 1,000.

Two remarks should be made on the subject of these statistics. The first is that out of the 29,308 workmen reported to have handled lead, a large number only handled it irregularly or to a slight degree. The second is that as regards sickness, only those effects of lead poisoning which cause working incapacity have been taken into account, and not, as in the French statistics reported above, blood changes and clinical symptoms.

The National Society of Painters of Great Britain records for the period from 1900 to 1923, 216 deaths among its members, of which 30 were due to chronic lead poisoning (13.8 per cent.), 24 to arteriosclerosis (11.1 per cent.) 123 to chronic nephritis (56.9 per cent.) and 29 to paralysis (18 per cent.). Besides, the society reports 674 other deaths which may be connected indirectly with lead poisoning. There were 203 deaths caused by diseases of the central nervous system, 460 deaths
from diseases of the circulatory system and
11 by diseases of the digestive organs.
From 1924 to 1925 the Society reported
14 deaths from lead poisoning.

Italy.—The Industrial Diseases Clinic
at Milan always follows up the state of
health of painters; Rubino (Genova, 1919)
made a very full enquiry into ship-paint-
ers; Ranelletti (1913) reported on house-
painters in Rome; Carozzi (1912-1914) made
a national enquiry upon the use of white
lead in the painting trade. These pursuits
carried out an enquiry concerning paint-
ers in Milan (1911-1931).

In Switzerland for 1901 to 1925, 278
deaths amongst painters were reported
as due to lead poisoning. According to the
statistics of the National Accident Insur-
ance Fund, from 1920 to 1925 the cases of
lead poisoning notified with a view to
compensation reached a total of 119; 106
were confirmed and granted compensa-
tion: 86 recovered; 8 involved invalidity
and another 8 were fatal; the result of one
case remained unknown. The 1920 Census
covered 5,154 painters.

United States.—An enquiry made by
the Commission of Industrial Diseases of
the State of Illinois has brought to notice
that among 578 cases of lead poisoning,
painters figure with a percentage of 27.
Dr. Alice Hamilton conducted in 1913 a
very exhaustive enquiry into the painting
industry; another enquiry by Hayhurst
dealing with 100 painters dates from 1914.
The result of a painting by Harris, relat-
ing to the state of health of 400 painters,
appeared in 1918. In 1917 Wade Wright
reported that during the first year’s work-
ing of the Industrial Clinic of the Massa-
chusetts General Hospital, 148 cases of
lead poisoning had been diagnosed, whilst
during the five preceding years only 147
cases had been reported in the different
departments of the hospital. Out of the
148 cases (of which 10 were non-indus-
trial), 70, that is to say, 50.2 per cent.,
ocurred among painters employed in
painting houses, ships or coaches. Ac-
cording to Hoffman, the causes of 2,783
deaths of painters were as follows:
pulmonary tuberculosis, 23.8 per cent.;
other respiratory diseases, 9.6; lead poison-
ing, 15; diseases of the nervous system,
10.7; of the heart, liver and kidneys, 25.9.

From 1914 to 1924 there were reported
841 deaths from chronic lead poisoning
among painters whose average age at
death was 51.3.

Chronic or acute nephritis accounted
for 193 cases (average age at death 49.2),
cardio-vascular diseases for 113 (32.8),
arteriosclerosis 97 (28.2), digestive dis-
ases 52 (43.7), respiratory diseases 44
(52.7), apoplexy 38 (52.6), anaemia 38 (54.9),
encephalopathy 23 (48.6), paralysis 23
(54.9), etc. It should be noted that of the
193 fatal cases among painters due to nephritis,
17.6 per cent., were aged 30-39; 31.1 at the
age of 46-49 and 29.5 at the age of 50-59
(Hoffman).

Another recent enquiry is that of the
Painters' District Council of Chicago
(1921). Detailed information was required
from its members as to the occurrence of
lead poisoning, of diseases of the heart
and kidneys, of inflammation of the joints
of the upper and lower limbs, and upon
accidents; it revealed that 53 per cent.
of members who replied to the question-
naire suffered from one or more of these
conditions which had caused a loss of
1,447 working days by 100 members during
the year 1921. The average age of mem-
bers was 42 years. Only cases of disease
recognised by a medical man have been
included in the statistics.

The most characteristic feature reported
on the subject of lead poisoning is its
considerable incidence during the first
decades, from ages 20 to 39. From ages
40 to 70 the disease seems to be stationary,
rendering, on an average, 17 per cent. of
members incapable of work. Although
the report does not give the reasons for
no greater increase among the old work-
men, it must be supposed that over 90
per cent. of the cases of sickness registered under general
terms and not requiring medical treat-
ment are nevertheless due directly or in-
directly to lead poisoning which may or
may not have been discovered by a meticulous
medical examination.

Six per cent. of members affected with
lead poisoning suffered at the same time
from diseases of the heart. As many
cases of heart disease may advance for
years without causing much suffering,
information given by individual members
cannot be relied on. In consequence the
report of the District Council takes into
account only those cases of heart disease
which prevent the patient from following
his usual occupation.

Under the heading "Diseases of the
kidneys" are entered non-specific cases
including acute and chronic nephritis.
Their incidence commences with 9 per
cent. between ages 20 and 29 and rises up
to 22 per cent. in the 60th year.

These figures show that most of the
workers affected by these diseases are in
the most active period of their lives, that
is, between 40 and 50 years.

The report presents the incidence of
these three industrial diseases (lead pois-
oning, diseases of the heart, and kidneys)
as follows: from ages 20 to 29 inclusive,
18 per cent.; from 30 to 39, 23; from 40
to 49, 34; from 50 to 59, 36; from 60 to 69,
51. It is only recently that inflammation
of the knee joint has been recognised as
an industrial disease of painters and infor-
mation on this subject is lacking.

Whereas the official report of the local
association (No. 194) for the years 1910-1920
enumerated 43 cases of inflammation of the
knee joint, elbow and shoulder with an
average duration of 47 days, the report
for 1921 based upon the information of
individuals contains figures which are
much higher; thus, 11 per cent. of cases of
inflammation of knee joint and 30 per cent.
for inflammation of the elbow and
shoulder. The last form of this affection
is the most common.

A report of the Association of Painters
of New York published in 1923 drew atten-
tion to the fact that certain workmen, without showing characteristic symptoms, are affected with chronic, ill-defined troubles which do not immediately permit of definite diagnosis.

As regards the frequency of accidents, the report emphasises that the number of fatal accidents is 15 per cent, higher for painters than for masons and bricklayers. It is considered that the inhalation of fumes is such as to produce serious organic troubles of which the first symptoms are headaches and vertigo; this would explain the frequency of accidents among these workmen.

If causes of death taking place among painters and the general population are examined, the rate for lead poisoning, in its cerebral and nephritic forms, is found particularly high for painters, who show a rate of 19 per cent, for tuberculosis, whilst that disease shows 10 per cent. for carpenters and 7.2 per cent. for an average population of at least 20 years of age (1930).

According to an official table, out of 9 trades that of painting shows the lowest average age; it does not in reality exceed 48.6 years. The statistics of the Association of American Painters show an age still less (45 years). According to these figures, the average expectation of life of a New York painter does not exceed 46 years, whilst for the rest of the population it is 62 years.

Hayhurst, who examined 267 painters who had worked in the trade for at least 7 years, and in the majority of cases for more than 15 years, reported, following on three successive examinations, that 60.33 per cent. suffered from occupational diseases, 33 per cent. from non-occupational diseases and less than 7 per cent. were in a normal state of health, and that was in spite of the fact that the majority of painters were young or of middle age.

The cases of lead poisoning notified to the Department of Labor in the State of New York during the period 1912-1925 numbered 890 with 105 deaths, of which 375 with 67 deaths occurred in the painting industry.

In 1924 Dean, of New York, described an epidemic of lead poisoning among painters employed on coach work in a motor-car factory at Detroit; 67 workmen employed in dry rubbing down coats of lead paint were admitted to hospital. The enquiry held by the Public Health Service of Detroit showed that these cases were caused by the inhalation of lead dust; that a handkerchief applied in front of the mouth and nose during one working day alone contained 84 mg. of lead, and that the injurious effect of work in the said factory was only due to an inadequate system of dust extraction.

First grinding, and then mixing and applying paint to new surfaces, create a risk of poisoning, especially by direct contact. The toxic product is introduced either in the course of the work itself, or, more particularly, during meal-times if the hands and the nails have not been scrupulously cleaned. Splashes of lead paint scattered upon the clothing, the ground, or the tools, on becoming dry disintegrate to liberate a poisonous dust. But the entrance by the respiratory system of dust and small drops must also be placed in the forefront, as well as poisons liberated as fumes, when cleaning by burning, or from diluents and the like.

The repairing of damaged surfaces not only entails the dangers of the preceding operations, when new coats of paint are applied, but the injurious nature of the preliminary cleaning process must not be forgotten. Whether through rubbing down with water or scraping the surface with metal and wooden instruments while dry, the old paint which is removed impregnates the hands of the workman and, by inhalation in the form of dry dust, may enter directly into the digestive organs or lungs.

As regards the causes of poisoning and the nature of attacks, they vary according to the nature of the substance used.

These are first and foremost pigments and compounds of lead, such as white lead, minium, and litharge, with the possibility of all the acute and chronic manifestations of lead poisoning. (See article "Lead Poisoning").

It is necessary to emphasise the grave danger involved in spray-painting when the paint used contains toxic pigments. In a German automobile factory, there occurred between 1921 and 1924 an actual epidemic of lead poisoning brought about by dry rubbing down of layers of paint applied by spray.

Of the 86 cases reported 72 affected workers engaged in dry rubbing-down, 4 of whom suffered from an encephalopathic form. Twenty-six workers had been working for a month at least, 7 for 9 weeks, and 1 for 3 days. In a handkerchief held in front of the mouth 84 mg. of lead were found.

Some other poisonous metals such as arsenic, mercury, copper, etc., are used, particularly in the composition of special products to prevent fouling; volatile substances, such as turpentine, benzine, methyl alcohol, white spirits, banana spirit, benzol and xylol, are used in the preparation of paints.
Poisoning, often of a complex nature, results, in which it is difficult to determine exactly the toxic agent or agents absorbed or inhaled.

According to Goadby, these different diluents and solvents are all dangerous and their use constitutes a very serious danger for painters.

In 1921 some English writers supported the hypothesis that among painters exposed simultaneously to lead salts and spirit of turpentine, it is not the lead but the spirit of turpentine which is the principal cause of certain conditions of ill-health, generally considered due to lead; particularly cardio-renal conditions nephritis and hyper-arterial tension.

It is not the first time, however, that this opinion has been put forward. It is of practical and fundamental importance. If it was correct it would seem useless to insist on white lead being replaced by harmless products, and the intention of laws made with this object would not be justified.

An enquiry by Heim, Agasse-Lafont and Feil, made with the object of casting light upon this problem, has established the fact that spirit of turpentine can certainly exert a toxic action on the organs; it is capable of causing complications in the kidneys (nephritis) or of the blood vessels (hyper-arterial tension). (See article "Turpentine").

But is this the case where spirit of turpentine is not absorbed but inhaled in small quantities? Can a chronic poisoning exist among painters which in the long run can cause nephritis or hypertension?

Spirit of turpentine is never employed alone in the preparation of colours; it is always mixed with oil in larger or smaller quantity, for colours prepared with spirit without the addition of oil would result in defective paint, as brittle as if the paint had been prepared only with water. When paint with a glossy surface is desired, much oil and very little spirit is used; when on the other hand paint with a flat or dull surface is desired, more spirit than oil is used. Glossy paints are generally divided into very thick ones (all oil, no spirit) and thick ones (half oil, half spirit); the first are used principally upon walls and exteriors; the other for kitchens and staircases.

Flat surface paint, also called sign-writing paint, contains two-thirds spirit and one-third oil; as it produces a handsome effect, it is reserved for reception rooms, halls and dining rooms.

Further, spirit, which is not so expensive as oil, is often used in bigger proportions than it should be, with a view to economy; but it is at the expense of the durability of the paint. These considerations apply as well to zinc white paint as to white lead paint, both of which include practically the same quantity of spirit of turpentine.

At this point it should be noted that oil mixed with spirit of turpentine materially prevents evaporation of the spirit, and, in consequence, danger which might result from its inhalation.

Now, the enquiry made upon 35 workmen who handled either spirit of turpentine alone or with white lead, as well as his previous enquiries, enabled Agasse-Lafont to come to the following conclusion:

Among working painters, though the inhalation of spirits of turpentine may exert an injurious effect upon the cardio-renal system, such effect will be in every case negligible in comparison with that caused by such salts of lead as white lead which should entirely, or at the least to a great extent, be held responsible for originating disease.

This opinion is supported by figures furnished by Dr. Stevenson, of the English Registrar-General’s Department, to the Commission of Enquiry Into Industrial Painting. According to this expert, mortality statistics do not confirm the hypothesis according to which turpentine is the cause of a great part of the excess of cases of nephritis among painters. He did not find in the reports relating to the last ten years any certificate attributing death to poisoning by turpentine.

Investigations made among workmen in contact with turpentine may also be quoted; they do not establish the existence of any special occupational pathology, nor of any of the symptoms peculiar to lead poisoning, e.g. colic, nephritis, paralysis, and the like. The same conclusion has been arrived at experimentally by Francioni (1924) who was able to show that poisoning by lead and by turpentine are absolutely different, particularly with regard to blood changes.

Injuries due to the inhalation of diluents and volatile solvents used in cellulose paints are referred to in the articles "Solvents", "Toluene", etc. Workmen who are employed in places of small dimensions and who, either on account of the actual work, or in order to obtain more rapid drying, have very often to use defective means of lighting and heating, are exposed to carbonic oxide poisoning. In the same way the repainting of double
bottnoms of ships necessitates a preliminary cleaning which entails a complete clearance, in the course of which deaths may occur from carbon or sulphur dioxide gases.

The occurrence of lesions, mostly produced mechanically, on the skin, mucous membrane and lungs should also be noticed.

So far as the skin is concerned, the lesions are due to the corrosive action of certain substances used before preparation work, especially for the prevention of fouling on ships, or for cleaning down with acids, soda, or caustic potash, or alcohol, or for cleaning machinery with benzene or petrol prior to painting; from these causes arise cracks on the ends of the fingers and changes in the nails.

The mucous membranes of the conjunctiva, larynx and bronchi are affected by the fumes set free by certain substances, especially when they are used hot, such as pitch, tar, varnish and bitumastic, which last is a patented material with a base of pitch and bitumen, possessing a strong odour of creosote and causing attacks of coughing.

The lungs may also become infiltrated with inert particles, the accumulation of which sometimes produces serious effects, resulting in pneumoconioses which may simulate tuberculosis clinically and radiologically. One form of pneumoconiosis is seen particularly among workmen who clean sheets of iron with the sand blast.

Two cases of poisoning by tetraline were reported in 1922 at Vienna by Arnstein. They were two painters who were working in a confined air space with bad ventilation, and showed irritation of the mucous membranes, marked lacrimation and headache. The urine was coloured green. The poisoning developed quite rapidly; albuminuria was reported as a sequela.

Goldmann (1930) met with a case of acute retrobulbar neuritis, due to using cellulose paint applied by spraying.

According to the reports of German factory inspectors, paint for boilers, containing as a solvent a homologue of benzene, caused nervous troubles of the hearing. Another containing an aromatic derivative (1931) known under the name of “Interol” caused cases of poisoning. Nitro-triphenyl methane, according to Sachs (1911), which had been used by a painter for nine months, caused tumours similar to papillomata, which occurred on the face and forearms.

Finally, in 1907, Gelly, of Nancy, who has studied the stigmata of decorative painters, said that he did not find the right thumb flattened as described by Tardieu, but had; on the contrary, found in seven workmen a callosity on the radial side of the right middle finger and another smaller one situated on the ulnar side of the right index finger. These callosities due to friction from the handle of the brush, held between the middle and index finger and kept in position by the opposition of the thumb, are said to be quite characteristic.

For the pathology of lead poisoning see article “Lead Poisoning”.

HYGIENE

As has been now seen, the principal danger to the painting industry is derived from the use of lead and its compounds. It is then the substitution of less harmful or inoffensive materials for lead which forms the first and most certain measure of prophylaxis.

In the naval departments of several countries, in particular France, a considerable move has been made in this direction by prohibiting the use of white lead, litharge and putty containing red lead and even of linseed oil fortified with litharge.

The French administration has also called for the suppression as far as possible of the use of red lead in paint, which should be reserved for exceptional cases where there is great and persistent dampness and maintenance work is very difficult, e.g. in holds and double bottoms, the lower parts of boilers, and propeller shafts. Particularly should the use of red-lead paint be given up for painting piping red; an artificial inoffensive vermilion should be used or some other special red, not containing lead, as for example the signal-red used for signalling on railways.

As regards house-painting, it is generally admitted that for white paints on interiors it is possible to do without lead. It seems that it is the same for the exterior. Zinc white paints, titan white, etc., can with advantage be substituted for white lead in the majority of cases.

In consequence of the necessity for allowing, on the one hand, the use of pigments containing a certain quantity of lead, as well as a small quantity of lead in the composition of dryers, and, on the other, the fact that it is desirable to allow the use of oxide of zinc made by the direct process, the English Departmental Committee on the Danger
of Lead Paints has considered the question of recommending a restriction upon the use of lead compounds by limiting the strength of soluble lead to a maximum of 5 per cent. In other countries similar conclusions have been adopted. Thus, for example, in France the Committee appointed to report upon the degree of purity of materials used in painting have recommended that materials which do not contain more than 3 per cent. should be considered as lead-free. In Belgium, the management of the State railways, where only leadless paints are used for all purposes, have fixed 4 per cent. as the limit. The Geneva Convention provides for a limit of only 2 per cent. of soluble lead (see later).

As regards coach-painting, it is above all fine carriage work which, on account of the great care taken and the long series of operations, gives rise to the greatest risks. The application of white lead for the first coats, called priming and preparation coats, and rubbing down, which should be done before the next coat is applied, constitute the two principal causes of poisoning to be avoided. Efforts are made to improve matters by replacing dry rubbing down with wet rubbing down carried out by means of pumice stone and water. But it must be said at once that from the technical point of view wet rubbing down is not accepted without reserve; for painting on wood, which does not stand moisture, dry rubbing down only may be recommended according to technical experts.

As for the suppression of white lead and other lead compounds, according to the English Committee’s report, the arguments in favour of a complete prohibition are more numerous than in the case of house-painting. There is reliable evidence that some important carriage building works do not use lead at all.

According to the New South Wales report quoted above, the Metropolitan Board of Water Supply, for example, has for two years (the date of the report is 1921) made great use of pigments with a zinc basis. The State railway workshops, where 400 painters are employed, use substitutes for white lead for the painting of the interior of railway carriages, and they even found a satisfactory substitute for painting the roofs of railway carriages. Cases of lead poisoning are very rare in these two concerns. In the tramway workshops at Randwick also very little lead paint is used. In the shipyards lead paint is used for the interior of ships, but only for the first coat of paint.

Other administrations have prohibited the use of white lead in carriage painting (as, for example, the Belgian and Italian State railways, etc.).

When lead compounds cannot be entirely abandoned, some temporary measures are useful to diminish much of the risk. As far as possible, contact by the workman with lead must be diminished, and the generation of dust containing lead must be avoided or the dust removed outside by localised exhaust draughts. Rubbing down with water has this in view, but its use is criticised as regards several kinds of work — upon wood and high-class work of the interior of houses — it has also the disadvantage of being more onerous and less rapid. There is also the further fact that the workman has his hands constantly smeared with a paste of white lead, exposing him to risk under another form, but perhaps as formidable. The inquiry of Heim, Agasse-Lafont and Feil has led them to the conclusion that men rubbing down with water exhibit, in a large proportion, the signs of lead poisoning.

The workmen should, in addition, be compelled to wear special overalls and to take them off as soon as they leave the workshop. Overcoats and outside clothes should naturally be kept in cupboards protected from dust. Washing accommodation, soap, nail brushes and towels must be provided for the workmen.

The workman must be warned of the danger. He must observe prophylactic measures for which his collaboration is necessary: no eating or smoking during work, thorough washing of the hands and mouth, cleansing of the moustaches and hair before meals and at the end of the day.

Periodical medical examinations are invaluable for detecting signs of lead poisoning. Reports of these signs, their degree and their aggravation, are salutary warnings which should cause timely and energetic action and so prevent serious developments. Blood examination in particular tends, from this viewpoint, to take more and more the place which is legitimately its due. The importance of systematic examination of the blood in the prophylaxis of lead poisoning has been repeatedly emphasised in France and Germany by doctors of the Health Insurance Offices and by experts. Nevertheless it must be confessed that to detect lead it is excellent in practice where work is carried on at a workshop or factory, insurmountable difficulties are met with as regards house-painting for reasons very easy to understand. It has had,
as a matter of fact, a complete setback in the countries which had adopted it — Germany and Belgium, for example.

Precautions of the same kind should be imposed for other poisonous substances which ought to be replaced as far as possible by less injurious or inoffensive products. The use of poisonous paints for spraying open surfaces should be forbidden unless the workman is protected in the most thorough manner. This method of painting small articles should only be done in a closed apparatus provided with an efficient exhaust draught.

Workmen exposed to poisonous fumes ought to use masks of known efficiency or work only under the protection of a current of fresh air, when painting, for example, in holds and cabins of ships.

A clinic reserved for members of the City of New York Painters’ Decorators’ and Upholsterers’ Brotherhood was opened in 1921. The painters are examined there medically once a year and can be looked after; and researches are pursued into means for combating industrial diseases among this class of workers. The clinic has been organised by the Health Service of the Painters’ and Allied Trades, a service instituted with the aid of the Workers’ Health Bureau, itself established in 1921.

It is interesting to note that under the auspices of the said Bureau an agreement for the protection of the health of painters — was signed in 1924 — between the Association of American Working Painters and that of the employers — the painters and decorators of New York. This agreement, which affects several thousand workers, lays down measures which concern the ventilation of places where painting work is carried on; and prohibits the use of paints containing benzol, lacquers dissolved in methyl alcohol, dry rubbing down, etc. It demands that the use of paints suspected of being dangerous may be regulated or prohibited after investigation by the Trade Board, and that receptacles containing poisonous substances be labelled.

The Health Service of Painters’ and Allied Trades of New York is certainly the first trade union institution organised for the purpose of preventing industrial diseases. The service was opened in July 1921, and the staff, under the direction of a medical man, includes a dentist, a nurse, a practical radiographer and a laboratory attendant. There is a radiographer’s department and a physiological laboratory, and the service has the advantage of the co-operation of eminent specialists in occupational pathology.

Among the agreements signed by the Industrial Diseases Clinic of Milan with the workmen’s associations is one which concerns painters and which has been included in the contract of work.

**Legislation**

For some time past, under the stimulus of the International Association for Labour Legislation, the protection of painters has been envisaged by certain States and certain local authorities who had already prohibited, for example, the use of white lead in the painting of public buildings. Regulation of the use of lead paints is intimately allied to regulation of the poisonous substance concerned (see articles “White Lead”, “Red Lead”, etc.) by measures controlling their sale, use, grinding in oil, and sale in receptacles with special labels.

Measures for the prevention of lead poisoning have been laid down in the form of a general ordinance in France (Ministerial Decree, 1 October 1913, in Great Britain (Factory and Workshops Act, 1901, Part I (i), section 1 (1, d)), and in Switzerland: in the United States in factory legislation where measures are laid down against dust and fumes (Iliinois, Act of 1911 amended in 1921; Missouri, Act of 1913; New Jersey, Regulations for the Lead Industries, 1914, Ohio, Act of October 1913; and Pennsylvania, Act of July 1913, for the prevention of lead poisoning). Measures for individual hygiene are provided by the United States (in the Acts of the States concerning work, lavatories, etc.); France (Ministerial Decree, October 1913); Great Britain (Women and Young Persons Act, 1900); British Columbia (Alberta: 1917, sections 28-31; British Columbia: 1911, section 12; Manitoba: 1913, section 132; Nova Scotia: 1901, section 16; Ontario: 1915, sections 39, 43; Quebec: 1909, Nos. 94, 104, etc.).

The First Session of the International Labour Conference (Washington, 1919) adopted a Recommendation on the protection of women and young persons against lead poisoning (see the article “White Lead”) and the Third Session adopted a Convention (see below). Legislation in accord with the Convention has already been passed by several countries.

Periodical medical examination is provided for by German legislation (half-yearly examination for painters and persons occupied in the colour and varnish industry) and by the Acts of monthly where more than 20 workmen are employed).

In Belgium the examination has fallen out of use since 1914 and has not been revived.

Legislation special to painters is in force in Germany: Order of 27 June 1905 regulating painting work of every kind in
workshops, shipyards or any undertaking. This Order prohibits direct handling of lead pigments in the dry state unless done in such a way that the workmen are protected from dust. It prohibits grinding and mixing these materials by hand; it prohibits scraping and dry rubbing down. It calls for compulsory wearing of overalls and head coverings during work; and for the provision by employers of all washing facilities for the workers. It makes it obligatory to instruct workmen as to the dangers of poisoning and as to the general precautions to be taken. It forbids eating and the consumption of alcoholic drinks in workplaces. It makes it obligatory to instruct workmen whose duty it is to spray paint containing white lead on the outside of buildings, and for those who are employed upon scaffolding and do occasional work.

In Austria the Decree of 15 April 1908 prohibits the use of lead paints for work on interiors and makes strict regulations of health records compulsory.

In Belgium an Act concerning the use of white lead and other white pigments of lead conforming to the scheme of the Geneva Convention, was passed in 1923. (See article "White Lead ").

In France the Act of 20 July 1909 only prohibits the use of white lead and linseed oil containing lead; it does not refer to other compounds of lead. The arrangements apply only to employees; the small employers working with their own hands can still use the injurious materials. Supervision becomes particularly difficult when a master, while working himself, employs workmen at the same time. Though the use of white lead is prohibited for house-painting, it nevertheless remains legal to use it for painting coaches, boats and ships.

Several countries which have not so far ratified the 1921 Convention have adopted measures of protection for painters: Germany (Order of 1930, Great Britain (Act of 1926), Switzerland (Federal Orders, 1928), etc. As regards spray-painting, certain legislative measures have been issued in the line of the Draft Convention of 1921 in: Czecho-Slovakia, Finland, France, Norway, Rumania, Spain and Sweden. Other countries have issued measures by special legislation: Germany (1930), Western Australia (1928), Belgium (1929), Great Britain (1926-1927), Northern Ireland (1928), Switzerland (1928), U.S.S.R. (1930) and several States of the United States of America.

In Yugoslavia the Act of 25 October 1921 provides for the prevention of lead poisoning by prohibiting manipulation of materials with a white lead basis with the bare hand, and dry scraping and rubbing down. In Czecho-Slovakia Regulations for painting work, decoration, etc., date from 12 June 1924.

On 5 August 1924, following a lawsuit brought by the Union of Painters and Decorators, a verdict was given by the Arbitration Court of Perth (Western Australia) which not only coincides with the scheme of the Geneva Convention (1921), but upon some points goes still farther. In fact, the verdict definitely fixes the maximum length of the working day and the number of hours per week, the tables of minimum rates of wages, compels the employer to allow the workmen five minutes for washing their hands before meals and before the end of work, and to supply the necessary soap and hot water. The grinding of white lead paints is prohibited inside buildings, and also dry rubbing down and scraping of lead paint, from three months after the date on which the verdict was given. An increase of wages is provided for workmen whose duty it is to spray paint containing white lead on the outside of buildings, and for those who are employed upon scaffolding and do occasional work.

The first Safety Code of the Association of Standards in Australia (Code for the Use of Paints, 1929) dealt with the prohibition of workers handling paints containing more than 5 per cent. of lead expressed in terms of metallic lead. It refers to decorative and commercial painting and painting in coach works and painting of vessels either with the brush or by spraying. The Code recommends the use of colours in the form of paste, or for applying the brush, labelling of receptacles, measures of personal cleanliness (working clothes, washing accommodation, etc., notification of cases of lead poisoning, cleanliness of tools, measures concerning the use of solvents (benzols, methyl alcohol, carbon bisulphide, etc.), exclusion of lead paints when the paint is applied by spray and indoors. Precautions in dry rubbing down, localised ventilation in spray painting of small objects, and the use of leadless paints in ship-building (interior work).

In U.S.S.R. the Commissariat of Labour has by Decree prohibited the preparation, sale, and use of white lead (18 January 1925). The Decree prohibits the erection of new white lead works, the exportation of this product abroad, and the registration of factories actually working. From 1 July 1925, the sale of white lead is prohibited in the dry state and only allowed if ground in the form of paste. From 1 January 1928 the use of white lead for the painting of the interior of houses was declared illegal, and from 1 January 1930 the sale, preparation and use of white lead in any form whatsoever was prohibited.

The International Labour Conference at its Third Session held at Geneva in October-November 1921 unanimously adopted the following Convention.

**Article 1**

Each Member of the International Labour Organisation ratifying the present Convention undertakes to prohibit, with the exceptions provided for in Article 2, the use of white lead and white lead pigments, of all products containing these pigments, in the internal painting of buildings, except where the use of white
lead or sulphate of lead or products containing these pigments is considered necessary for railway stations or industrial establishments by the competent authority, after consultation with the employers' and workers' organisations concerned.

It shall nevertheless be permissible to use white pigments containing a maximum of 2 per cent. of lead expressed in terms of metallic lead.

Article 2
The provisions of Article 1 shall not apply to artistic painting or fine lining.

The Governments shall define the limits of such forms of painting, and shall regulate the use of white lead, sulphate of lead, and all products containing these pigments, for these purposes in conformity with the provisions of Articles 5, 6 and 7 of the present Convention.

Article 3
The employment of males under eighteen years of age and of all females shall be prohibited in any painting work of an industrial character involving the use of white lead or sulphate of lead or other products containing these pigments.

The competent authorities shall have power, after consulting the employers' and workers' organisations concerned, to permit the employment of painters' apprentices in the work prohibited by the preceding paragraph, with a view to their education in their trade.

Article 4
The prohibitions prescribed in Articles 1 and 3 shall come into force six years from the date of the closure of the Third Session of the International Labour Conference.

Article 5
Each Member of the International Labour Organisation ratifying the present Convention undertakes to regulate the use of white lead, sulphate of lead and of all products containing these pigments, in operations for which their use is not prohibited, on the following principles:

I. (a) White lead, sulphate of lead, or products containing these pigments shall not be used in painting operations except in the form of paste or of paint ready for use.

(b) Measures shall be taken in order to prevent danger arising from the application of paint in the form of spray.

(c) Measures shall be taken, wherever practicable, to prevent danger arising from dust caused by dry rubbing down and scraping.

II. (a) Adequate facilities shall be provided to enable working painters to wash during and on cessation of work.

(b) Overalls shall be worn by working painters during the whole of the working period.

(c) Suitable arrangements shall be made to prevent clothing put off during working hours being soiled by painting material.

III. (a) Cases of lead poisoning and of suspected lead poisoning shall be notified, and shall be subsequently verified by a medical man appointed by the competent authority.

(b) The competent authority may require, when necessary, a medical examination of workers.

IV. Instructions with regard to the special hygienic precautions to be taken in the painting trade shall be distributed to working painters.

Article 6
The competent authority shall take such steps as it considers necessary to ensure the observance of the regulations prescribed by virtue of the foregoing Articles, after consultation with the employers' and workers' organisations concerned.

Article 7
Statistics with regard to lead poisoning among working painters shall be obtained:

(a) As to morbidity — by notification and certification of all cases of lead poisoning.

(b) As to mortality — by a method approved by the official statistical authority in each country.

By 1 January 1934 the Convention concerning the use of white lead in painting has been ratified by the following States: Austria, Belgium, Bulgaria, Chile, Colombia, Cuba, Czechoslovakia, Estonia, Finland, France, Greece, Latvia, Luxembourg, Norway, Poland, Rumania, Spain, Sweden, Uruguay, Venezuela, Yugoslavia. Ratification has been approved by the competent national authority in Italy and the Netherlands and recommended for approval in Argentina.

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Paper Mills


Paper consists essentially of a thin felted web, tissue or fabric resulting from the interlacing of vegetable fibres, the principal constituent of which is cellulose. The determining feature of a good quality resides in the distinctly fibrous structure of the raw material. This structure determines the nature and variety of the operations to which the various vegetable fibres are subjected.

In the earlier stages of the paper-making industry production was effected either by mechanical treatment of fibrous leaves or by chemical treatment of linen rags, cotton, flax and straw fibres, esparto and other cellulose parts of plants. It was not until the middle of the nineteenth century, however, that a suitable raw material was obtained from wood for the industrial manufacture of paper on a large scale, rags being exclusively retained for the preparation of special types of paper (paper of superior quality).

TECHNICAL DATA

A. — Raw Materials

Rags (see that article) of flax, cotton, etc., are opened out when they arrive in bales, freed from dust by heating, sorted and graded according to the nature of the material, the fibre and the colour, shredded either by hand, or in a special machine known as a "willow", and sometimes cleaned mechanically in a drum washer which may be combined with the breaking machine.

Waste material (scraps and ends from clothing establishments), together with pieces of linen, rope or string, etc., are included in this type of raw material.

Subsequent to cleansing with quick-lime, caustic soda, carbonate of soda or a mixture of that with lime in boiler, the water is allowed to drain off and the rags are passed on to breaking machines, in which bleaching by chloride of lime may also be effected. Impurities and soluble substances are carried off by water, and there is obtained at this stage the "half stuff".

Various types of straw — wheat, oats, barley, and especially rye — are first of all cut up in a grinding machine and then freed by a current of air from any dust and impurities they may contain. They are subsequently cleansed by boiling under high pressure and at a high temperature. The straw pulp or paste obtained is


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washed, drained and passed on to the process of bleaching. Straw requires a large amount of caustic soda for cleansing. Esparto (alfa) straw is submitted to the same treatment as other kinds of straw; being less ligneous it requires less energetic treatment. After opening of the bales it is subjected, passed through a lye solution, washed in water or steam, drained and sent to the breaking machines. The "half stuff" obtained is then sent to be bleached.

Old paper is submitted to operations of sorting, breaking, boiling and washing.

Wood is at present the most important raw material for the paper industry. It is transformed into wood pulp or "half stuff" by three different processes: mechanical process, chemical processes, and steam process.

(a) The mechanical process gives a mechanical pulp used for paper of ordinary quality, and especially for newspaper. The wood is cut into well-barked logs which are freed from knots and are about 30-50 cm. in length. These are disintegrated in a revolving grinding mill which liberates the fibres. These fibres are then carried away by a current of water towards cylindrical machines which effect further grading and they are thereafter directed to a bolting machine. If the wood pulp is for immediate use it is drained; if for export, it is put through a press and centrifugal dryer.

(b) The chemical processes employed comprise treatment with caustic soda, treatment with sulphate and treatment with bisulphite. In the first process the wood, after being cut into small round pieces or shavings, is subjected after boiling to high pressure in a pulp digester. A caustic soda lye is introduced and brought to a high temperature. The pulp is washed in stacks or in a washing machine. The lye is recuperated and concentrated, and about 70 per cent. of the caustic soda used is recovered. The sulphate treatment is a variant of the caustic soda treatment, sodium sulphate being added to the regenerated soda instead of the more costly carbonate.

This method produces organic sulphurated compounds which render its application almost impossible in inhabited centres. There should also be noted the importance of the processes for recuperation of by-products derived from the pulp (resin, turpentine, etc.). The bisulphite treatment utilises a solution of bisulphite of lime or magnesia. There is also used a solution of sulphur dioxide and of sulphite of lime. Sulphur dioxide obtained by treating sulphur pyrites in special furnaces is cooled, led into receptacles containing the calcarious material and brought into contact with a water spray which enriches the sulphur dioxide and bisulphite of lime. The wood undergoes a series of more complicated operations than those necessary in the treatment by caustic soda. The by-products contain ethyl and methyl alcohol, turpentine, tannic substances, lignosol, etc.

(c) The steam process which gives a semi-chemical pulp consists in treating the wood with steam at high pressure. The "half stuff", of a brownish colour, is chiefly used in the manufacture of brown wrapping paper. During the manufacture of paper a certain amount of waste is obtained ("broke") which, together with rejected paper and paper slightly soiled by use, etc., is re-utilised in the manufacture of new paper. The "half stuff" obtained is of a mediocre quality.

B. — Manufacture of the Pulp

This comprises bleaching, refining, and the addition of loading, sizing and colouring materials.

Bleaching, the object of which is to free the fibres from all non-cellulose components, may be effected in accordance with three different processes: bleaching by chloride of lime, bleaching by chlorine fumes and electro-chemical bleaching.

The chloride of lime process is sometimes effected in a breaker taking the form of a stack, or more often in a special type of stack known as a bleacher.

The chloride of lime is diluted with a volume of water sufficient to permit of effective mixing of the mass. Washing and draining follow. Chlorine fumes are obtained by causing hydrochloric acid to act on manganese peroxide. This is a violent bleaching process which demands more manipulation than the above chloride of lime process.

In electrolytic bleaching a solution of alkaline chlorides (sodium, magnesium) is decomposed by means of an electric current.

Beating, which constitutes a process of refining, has for its object to impart to the pulp as it leaves the bleaching stacks a certain homogeneity of texture. This operation is effected in special stacks.
The addition of loading materials (clay, calcium sulphate, "pearl hardening," kaolin or china clay, casein, rosin, gelatine, talc, ochre, etc.) is usual in the manufacture of all kinds of paper except for very superior qualities.

Sizing, the object of which is to prevent the paper from absorbing ink, is effected by the use of rosin soap (added to the beater before the pulp goes on the wire and known as "engine-sizing") fixed by means of alum or aluminium sulphate. Sometimes felcia, starch or gelatine is used. Gelatine-alum sizing is required for hand-made papers ("animal" or "tub-sizing"). Sizing is applied in a different manner according as to whether the paper in question is intended eventually for printing or for writing.

Colouring of the pulp may be effected by aniline colouring agents or mineral substances. Smalls", finely powdered glass, coloured with cobalt blue, are used for hand-made papers. Ochre colouring agents are used to a certain extent and constitute at the same time loading materials. Chrome yellow, ultramarine blue, Prussian blue and indanthrene blue (for high-grade papers), and for newspaper methyl and ethyl violets, blues, greens and reds, are also used.

C. — Manufacture of Paper

The "half-stuff" prepared in paper factories or bought from the pulp factories serves in the manufacture of hand-made (very little practised) and machine-made paper.

Mechanical manufacture of paper comprises a long series of operations, which may be briefly enumerated as follows: mixing and stirring of the pulp slurry in mixing vats and "stuff chests". The pulp is fed in a continual stream, by means of regulating drums, into a continuous machine and is led by means of special piping to sand tables or a sand trap which retains impurities, and thereafter to purifying filters or strainers which remove knots, lumps, etc. It is then transported to the "breast box" and thence to an endless wire cloth made of brass wire mesh, which covers the manufacturing bench, the first portion in which the pulp slurry is transformed into a wet web being designated the "wet end" and the drying and finishing portion the "dry end". Exhaust hoods arranged under this bench remove the greater part of the water from the pulp. The sheet of paper thus commences its formation. It is afterwards pressed between two cylinders covered with felt, for the purpose of rendering the fibres still more dry. It then passes over an endless belt of felt, which transports it successively to cylinders of the first press and, finally, to the second press.

The sheet of paper thus formed is then led to drying cylinders varying in number and steam heated, usually separated by "din rolls" or smoothing — in order to flatten the paper before quite dry — which completes the operation of drying. Both sides of the paper are made thin and smooth by passing through calenders. Better-class types of highly glazed papers undergo additional treatment in super-calenders consisting of a stack of rolls alternately of heated cast-iron and compressed cotton or paper. The sheet is thereafter rolled in the form of a reel.

The successive operations comprise glazing, cutting (lengthwise or in reams), inspecting and packing.

Hand-made paper is used for special purposes such as banknotes, Government stamp-paper and high-grade paper. For this purpose the pulp prepared from unbleached rags is run into "stuff chests" and thence into vats and, after maintaining, is made on a wire cloth mould surrounded by a movable frame or "deckel", which is dipped into the vat. It is then shaken to cause felting. The "deckel" is removed and the mould is inverted on to and pressed against a felt, being transferred, or "couched" from the wire to the felt.

The sheet of paper is then covered with a piece of felt of the same dimensions and inserted into the stack, and the stack of sheets and felts passes into a press with the object of removing the excess water. The felts are thereafter removed and the sheets of paper pressed between plates in order to remove the marks left by the felts. Sizing is effected by passing the sheets through a tub of hot solution of gelatine or vegetable glue, or "hand sizing", or through a gelatine solution containing a large percentage of alum. The operations of dressing, drying and glazing, and stretching of the sheets one by one follow.

Mention may here be made of the manufacture of cardboard on a huge continuous machine, the making of cardboard and paper, and the varieties of manufacture of special kinds of paper. Amongst these reference should be made to parchment paper (unpashed paper attacked by sulphuric acid), waterproof papers (impregnated or coated by coal-tar pro-
ducts, pitch, resin, paraffin or vegetable or mineral oils), cardboards treated with bitumen obtained by plunging the cardboard into a vat containingitur heated to a certain temperature (one layer being covered with sand), glass paper, emery paper, flint paper (obtained mechanically), glazed and coloured papers (by application of colouring agents and talc), gilded and marbled papers (treated in vats or by machinery), wallpapers (preparation of colouring materials, printing or designed by machinery), gilded papers, velvet papers with design in relief, washable papers, etc., playing cards.

It should, in conclusion, be remembered that the paper industry consumes chemical products and mineral and organic materials in ever-increasing quantities (referred to above), as well as large quantities of water. The latter ought to be of guaranteed purity, free from mineral or organic matter in suspension, and free from certain salts, notably salts of iron.

**Sources of Risk**

Brief reference may be made to the risk of accident, which is naturally dependent to a great extent on the industrial methods followed. According to Lorange, the annual number of absences due to accidents was in Norway, during the period 1922-1927, 17 in the grinding shops, 12 in the pulp factories, and 15 in the wood-pulp factories.

Certain categories of workers are more exposed to risk of accident than others — for instance, workers engaged in removing bark by machinery, in sawing or in cutting of the wood, or in shredding in a grinding mill for obtaining mechanical pulp, which involves exposure to burns or splashings of the hot pulp. The risk is great in the older types of workshop, where barking of the wood and cutting of the pulp are done by hand.

The great source of risk in the manufacture of wood pulp and in that of paper is humidity. Often the flooring is wet and slippery, especially in those factories which follow the sulphate process, with the result that accidents due to falls are not uncommon.

A hot and humid atmosphere is typical also of the drying rooms and of the workrooms for the pressing and drying of the pulp and for the manufacture of paper. According to Pedley, it is necessary to evaporate 2 tons of water in order to make a pound of paper, with the result that machines delivering 80 to 90 tons of paper per day evaporate 7 to 8 tons of water per hour.

High temperatures are met again in boiling and washing rooms and in workrooms for the manufacture of paper by continuous machinery where operations of recuperation are carried out (sulphate and soda processes)

Obviously, during winter the presence of steam often renders the atmosphere disagreeable and hinders the work.

An enquiry effected in 1926-1927 by Atterbom in regard to the state of the atmosphere in thirty-two Swedish pulp factories gave relatively unfavourable results. It must, however, be stated that improved ventilation installed in many factories in the course of the last three years has succeeded in rendering the atmospheric conditions almost satisfactory.

The products used (alkalis), as well as those liberated in the course of the various operations in the chemical pulp industry, constitute the source of various health risks.

In the sulphate process, for instance, there is the formation of mercaptans, sulphuretted hydrogen and methyl sulphide fumes, which, however, can easily be captured and evacuated by modern technical methods. On the other hand, fumes charged with nauseous gases which are emitted from the autoclaves are more difficult to eliminate in a satisfactory manner. These gases, however, should not be considered as dangerous, nor even as presenting great inconvenience for the workers. The recuperation of sodium sulphate and caustic soda from the boiling liquid liberates large quantities of nauseous fumes (mercaptans), which, however, only constitute very slight inconvenience in modern factories with adequate hygienic plant.

Filtering and drying of the pulp and cleaning of drying machines expose the workers, especially in winter, to damp and to chills in older factories or where the workrooms utilised for these processes are underground.

Clouds of steam liberated from continuous machinery at the moment at which the leaves of paper, still damp, pass through the first drying cylinder constitute not only an important source of risk for the health, but also a hindrance from the technical point of view (interfering with the conservation of metallic structure, condensation of drops of water on the reels in course of formation, etc.).

The typical risk connected with the sulphite process is due to the presence
of sulphur dioxide in the dust raised by the pyrites and sulphur and other sulphurous substances employed in the preparation of sulphur dioxide. These unfavourable elements may be reduced to a minimum by adopting the system of closed transporting machinery, air-right piping, and adequate mechanical plant.

The preparation of chloride of lime used for bleaching the pulp exposes workers to the liberation of dust and fumes of chlorine gas.

Another form of risk is represented by the great heat given off from the sulphur dioxide furnaces when there is no automatic system for charging these.

In the course of the last thirty or forty years, during which the manufacture of wood pulp has developed into an extensive industry, sanitary improvements have succeeded in attenuating or eliminating the majority of health risks experienced by the workers. Yet there remain as potential sources of risk certain inherent factors connected, for instance, with gas escapes, ruptures of pipes or furnaces containing sulphur dioxide, or, again, connected with the large quantities of toxic gas capable of invading the whole factory in case of accident.

Where a factory utilises rags, steps must be taken to prevent the danger of infection proceeding from the dust raised during manipulation or storage of these. In an enquiry covering eighty establishments, the Massachusetts Board of Health ascertained the fact that where clean rags are used, little dust is involved by their manipulation, but that the rags generally used liberate much dust, whatever kind of plant or systems of ventilation are applied (Kober).

Sorting of old papers is equally a dusty and very unhealthy operation (Bailly).

Certain types of dust (alum, resins) and notably those liable to contain lead or resin might — especially in former times, since they are at present prohibited in most countries — likewise represent a source of risk.

Chmaladze (1925) referred, in addition, to the following harmful factors: fatigue of the senses of touch and of sight and overstrain of the capacity for attention, tension and uniformity of muscular movements and of the movements of the upper limbs.

Attention should finally be made of causes of inconvenience affecting the neighbourhood. Pulp factories may liberate disagreeable and nauseous odours which invade the atmosphere for miles around, and which are due principally to mercaptans. Diluted as they are, these gases cannot in practice produce toxic effects, yet their nauseous odour may seriously affect the comfort and welfare of inhabitants in the neighbourhood. It would, however, appear that many people become rapidly accustomed to them and are not further affected by them.

**Statistics**

Statistics relative to health conditions of workers engaged in the wood pulp and paper industries are not numerous.

In Sweden a detailed enquiry effected in 1913-1914 at the instigation of the Minister of Labour dealt with the health of the staffs of thirty-seven out of eighty-four of the wood-pulp factories then existing in the country. On the basis of notifications lodged by twenty-seven factory doctors, it was ascertained that the state of health of the workers in wood pulp factories and of those inhabiting the neighbourhood of these factories was not worse than that of workers in other industries (sawmills, for instance) or that of workers inhabiting neighbouring regions or of agricultural workers.

Medical examination of 239 workers employed in the pulp factories engaged in the bisulphite or sulphate process only revealed 3 cases of latent pulmonary tuberculosis, 20 of bronchitis, 6 of kidney troubles, and 31 of rheumatism.

In accordance with information which Würzen was able to collect in 1930 from forty-one factory doctors engaged in wood-pulp and paper factories, the state of health of the workers engaged in this industry is not in any respect worse than that of the remainder of the population. Certain doctors even expressed the opinion that, as regards tuberculosis, the workers in this industry were in a more favourable position than the other inhabitants in the region.

In a factory known as one of the oldest in the world, there were found workers enjoying excellent health.

In Germany, according to the statistics of the Leipzig Sickness Fund (1910) workers in paper factories in the age-group 15-34 showed 67.9 cases from all diseases per hundred workers employed as against an average of 36.6 for all occupations, and 77.7 for the age-group 35-54 as against an average for all occupations of 44.4. Respiratory diseases, including tuberculosis, showed relative figures of 10.2 and 12.5 for the two age-groups in question, as

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1 According to Fischer and Penzoldt, mercaptan liberates a very strong odour with a dilution of 1/115,000 mg. per litre of air, and its sickening odour is said to be even distinct at a concentration of 1/23,000,000 mg. per litre of air (Lit.: Ann. de Chimie, 1887, p. 131).
contrasted with an average of 5.6 and 7.6; diseases of the muscles and joints 7.4 and 11.2, against 2.8 and 6.3; and accidents 22.1 and 25.4, as against averages of 9 and 9.7.

Similarly, data with regard to the mortality of workers in paper factories are neither abundant nor typical. According to the Report of the Registrar-General for England and Wales for 1921, for example, the manufacture of paper is stated to be a healthy industry, since the workers engaged in it show a comparative mortality figure of 761 (standard figure, 1,000) and a mortality rate at all ages upwards of twenty-five which is inferior to the average.

PATHOLOGY

The occupational pathology is essentially dependent on the nature and manipulation of the alkaline liquids, which cause these lesions. The lesions in question are naturally more serious in the case of the use of hot lyes.

In summer, when there is profuse perspiration, these products set up dryness and irritation of the skin, and it is then advisable to institute short working shifts where mechanical processes have not been installed.

Robertson refers to the possibility of chlorine acne affecting bleachers of wood pulp.

The colouring agents utilised may give rise to types of dermatitis, but the quantities used are small, and the number of workers who handle them is likewise very limited.

Fig. 52. — System of ventilation adopted in a paper factory. Elevation and cross section.

methods of production of the pulp. The manufacture of paper is not very trying work, and may even be engaged in by workers of weak constitution (Beiniker).

Contact with the numerous chemical products, and particularly the alcalis utilised during the preparation of the pulp, its bleaching, etc., is, of course, liable to cause dermatitis and lesions of the mucous membrane and nails. It is in particular such products as quicklime, caustic soda, chloride of lime, carbonate of lime, sulphate of soda, and the bisulphides, etc., either during recuperation of the lyes used (Pedley) or during preparation and

In 1929, Taginuchi drew attention to the occurrence of a form of dermatosis known locally under the name of "sadare" or "tako", and due to a blastomycete which affected the paper works in the province of Gifu (Japan), and which he himself designated as _erosio interdigitalis blastomycetica_. This dermatosis, which occurs in summer and more rarely in winter, is located in the interdigital spaces, and consists in maceration of the skin, followed by erosion, with violent itching. Slight cases of bronchitis and colds are not of rare occurrence, but these manifestations may be considered as a reactivation of a slight chronic state
of irritation of the respiratory passages, to which these workers have become accustomed.

Rheumatism due to the hot and humid atmosphere is said to be fairly frequent (Wirgin).

The effects of sulphur dioxide appear to depend to a great extent on individual susceptibility. Numerous workers possess almost total immunity to the amounts of this gas generally encountered in the atmosphere of factories, whilst others react by irritation of the upper respiratory passages (fits of coughing, breathlessness).

As a general rule the workers become quickly accustomed to the atmosphere, and certain experts even consider that sulphur dioxide exerts a favourable action on health, protecting the workers against influenza and colds.

Anaemic and weak individuals complain of stomach derangement and vertigo, which they attribute to the effect of sulphur dioxide (Beintker).

Cases of acute bronchial catarrh are of relatively frequent occurrence amongst those who work in a hot and damp atmosphere (wood-pulp factories) and are exposed to sudden changes of temperature, and patients are said to recover less rapidly when continually exposed to an atmosphere charged with sulphurous fumes than if they were working in the fresh air.

The same should be said of workers engaged in tending the continuous machinery, who, besides suffering from respiratory affections, are often affected with rheumatic pains (Gaudiot).
The inhalation of methyl sulphide and of methyl disulphide is said to have caused several deaths amongst workers in Finnish factories utilising the bisulphide process.

It is hardly necessary to refer to accidents of various types which may arise from the use of machines for barking of an ancient pattern, from the use of boiling liquids, etc., or from falls due to slippery flooring on which sulphate solution has been spilt, etc.

It may be said in conclusion that work in the pulp and paper factories does not involve any essential or specific risks for health where it is effected under normal conditions and with provision of adequate measures of accident prevention.

**HYGIENE**

General measures of hygiene comprise the construction and maintenance of the factories (situation, lighting, temperature and humidity, cleanliness, cloakroom and canteen accommodation, etc.).

Special measures of hygiene peculiar to pulp manufacture and the paper industry consist principally in collection, elimination or neutralisation of products liberated or which are transformed into residues in the course of preparation of the chemical pulp (sulphur dioxide, mercaptan, turpentine, methyl-alcohol, methyl-sulphide, etc.).

The provision of adequate apparatus for localised ventilation and the provision of fresh or warm air, as the case may be, in the workrooms is important.

Furnaces, autoclaves, piping, etc., should be constructed in accordance with the principles of modern technique. High chimneys should be provided to facilitate dispersion of smoke in the atmosphere.

Dust should be collected and removed (from pyrites, carbon-dioxide furnaces, sulphur, chloride of lime, etc.) by means of suitable devices.

Transport should be effected in closed receptacles. Localised ventilation combined with good general ventilation is very effective in operations connected with manipulation of rags (see that article), sorting of old paper, cleaning of wood, etc.

Dusty operations should be effected in separate workrooms. The dust collected often contains important products which it is advantageous to recover.

Respiratory apparatus and masks, though essential in certain repair work and difficult operations connected with emptying and cleaning boilers, etc., are on the whole too uncomfortable to be tolerated during ordinary work and cannot be worn for long at a time.

Certain firms place at the disposal of their workers special solutions intended to neutralise acids.

It is desirable to have adequate and effective means of ventilation to attenuate the inconvenience of undue heat and humidity, especially in pulp factories, where treatment by hot processes liberates at times considerable quantities of steam.

Clouds of steam forming over the continuous machinery should be as far as possible absorbed and dissipated by means of the introduction of hot air at the level of the drying rolls.

Fig. 52 shows the system of ventilation adopted in one paper factory. The fresh air arrives in the workroom through the roof and is exhausted through a heating apparatus whence the air is blown out into different parts of the factory. It is important that the dry, warm air should be distributed to the machine room from the adjoining workrooms by passing through apertures close to the floor. The exhausted warm and humid air from the paper machines gives off its heat to the fresh air by passing through the heating apparatus on the top of the building prior to being cast outside.

Workers should be protected against humidity (provision of waterproof overalls, aprons, etc.).

During operations in the course of which workers are exposed to splashing of liquid (bleaching of pulp), the floor should be kept in a satisfactory condition of cleanliness, especially near the vats, where the passage of heavy loads and the effect of acid solutions are liable to render this somewhat difficult.

The addition of toxic colouring materials to the wood pulp should be prohibited and they should be replaced by the use of harmless products.

All rags should be disinfected, and the staff called on to manipulate these should be vaccinated against smallpox.

Adequate means of individual protection against accidents should be taken — such, for instance, as the wearing of glasses to protect the eyes from particles of wood, harmful fumes, etc. — and likewise adequate protection against contact with machinery should be ensured.

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1 According to Rekowski, the quantity of methyl-mercaptans capable of causing poisoning and death to an adult may be reckoned respectively at 1.750 and 9.100 mg. (Arch. science biol., 1893, Vol. II, p. 263.)
Workers subjected to the effect of sulphur dioxide should be transferred from time to time to workrooms where this gas is not present to any extent.

The question of the disposal of waste water (see article "Industrial Waste Waters") is highly important. Waste water from the paper factories may not be evacuated into water courses without special treatment, for the small particles of fibre which it contains, the presence of sulphur, of colouring materials or putrescent substances are liable to injure fish and plants. Waste waters should therefore be decanted in sedimentation tanks and filtered over cinder filters (biological purification) prior to being evacuated.

It is further of every advantage to factory management to recuperate, as far as possible products contained in these waste waters or to regenerate other products (soda lyes from the pulp).

The lyes coming from the sulphite process after passage through steam give a black, sticky mass utilised for pulp making (Beintker).

Methods of treating residues and waste waters adopted in recent years by pulp factories have succeeded in attenuating or even eliminating the harmful effects of these factories on the neighbourhood.

LEGISLATION

In Spain, boys under fifteen and girls under twenty-one are excluded from the sorting and preparation of rags, and likewise in Italy, unless adequate apparatus for elimination of dust is provided. They are also excluded from colouring of paper by means of toxic products. In France, boys under eighteen are excluded from the sorting and preparation of rags. In Greece, boys under sixteen and girls under eighteen are excluded from certain operations. In certain of the United States, young persons are excluded from tending machinery for making glass paper, etc.

In Austria, the Order of 25 September 1911 contains provisions of safety and hygiene relating to workers occupied in paper manufacture. It prohibits manipulation of contaminated or insufficiently disinfected rags, provides for dry cleaning of rags by mechanical means, and likewise for the sorting and shredding of these in special workrooms. It regulates also the cleaning and ventilation of workrooms, requires provision of lavatories, cloakrooms, baths, working clothes and respiratory apparatus. The Order prohibits smoking and the consumption of food in workrooms.

Resolutions passed by the State Council in Finland and dated 30 December 1924 deal with factories engaged in cutting and grinding wood, paper factories and factories engaged in the sulphite and sulphate treatment of cellulose.

In Belgium, France and Italy, paper factories are subjected to measures provided by the Acts dealing with trades scheduled as dangerous, unhealthy and offensive.

The Compulsory Order dated 3 November 1922 issued in the U.S.S.R. concerns the installation and maintenance of paper factories.

In Czechoslovakia the Regulation of 26 May 1923 contains measures analogous to those included in the Austrian Order referred to above, and contains the further clause that persons subject to epilepsy, cramp, syncope, vertigo or suffering from deafness or other defects or physical infirmities shall be excluded from such processes as involve serious risk.

A similar Regulation was adopted on 25 October 1921 in Yugoslavia.

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Figs. 52 and 53 are reproduced by courtesy of Dr. C. Naeslund.

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(Sweden.)

Paraffin


CHEMISTRY

Paraffins are generally mixtures of the higher saturated hydrocarbons of the methane series \((\text{C}_n \text{H}_{2n+2})\) boiling at high temperature (from the octadecane \((\text{C}_{18} \text{H}_{38})\) to the penta-triacontane \((\text{C}_{30} \text{H}_{62})\) and are therefore called, because of their inactivity from the chemical point of view, "parum affinis": slight affinity.

Paraffins are obtained by the distillation of petroleum lignite tar, bituminous
PARAFFIN

The paraffins set up occupational lesions in the distillation of petroleum, tar, etc., for the workers cannot avoid soiling themselves, particularly when cleaning the pipes, retorts, tanks, etc., containing the resinous residues, and in working and cleaning the filter presses. The persons engaged in cleaning the receptacles especially come into direct contact, for hours at a time, with hot masses of paraffin and their fumes. The use of paraffin and like compounds may also be prejudicial to health.

The paraffins exert not only a local external action on the skin and mucous membranes but also a general action due to the absorption either of the paraffin or inhalation of the volatile compounds. The action on the skin is firstly mechanical (the particles obstruct the pores, the orifices of the sebaceous and sweat glands, from which arrest of the secretions and a very remarkable irritant action results), and secondly chemical. The gaseous or liquid hydrocarbons, alone or as compounds of crude paraffin, dissolve the fatty covering of the skin and thus remove its natural protection. In many cases the impurities irritate the skin on account of the oxidisable substances, i.e. the non-saturated hydrocarbons, terpene, acids, lime salts, sulphates, phenols, cresote, ichthyol, empyreumatic substances, or of the chemical residues left in purification (alkalis, sulphuric acid).

The most important action, however, without doubt is that of inducing proliferation of the epithelial cells (dermatitis from crude oil and paraffin, paraffin cancer), an action very variable and related to the degree and nature of the impurities contained in the paraffins. Really, the latter, deprived of their empyreumatic substances and of the chemical products added for their purification, do not exert an irritant action. Experience with "war vaselines" therapeutically used is very interesting in this respect. When these were used as ointments or cosmetics, acute and chronic eczematous affections of the skin were produced. Besides folliculitis, with or without comedones, analogous to those found in petroleum and paraffin workers, etc., warty growths have been observed on the body, especially on the face. In this case, it is a question of abnormal epithelial proliferation with keratosis associated with an inflammatory infiltration of the upper cuticular layers. On the covered parts of the body...
papular outgrowths or warts are observed, horny protuberances associated with pruritus, and burning sensations. followed by headache, fever with a temperature of 40° C., nephritis, etc. In children, headache, palpitation, dis-

Among the general manifestations, excitement and insomnia have been noted. Its use by injection has been quieting cyanosis, vomiting, weak pulse, somnolence, etc., occur. In the later occurrence of pigmentation and
melanosis, no doubt certain photochemical actions come into play. It is a question of the peculiar, well-known property belonging to certain chemical bodies, among which are certain derivatives of naphtha, such as vaseline and paraffin, of setting up, in the presence of light, the morphology and physiology of unicellular animalcula and agglomeration of cells, whereas in the dark they are without action. The human skin is very sensitive to traces, even infinitesimal, of these substances which “sensibilise” it to the photochemical action of these common rays;

FIG. 55. — Chronic indurated dermatitis (warts, scars).

The numerous researches undertaken.
FIG. 56. — Papular dermatitis (after two months' work).
with the object of isolating the active agent have not, up to the present, been successful. Although acridine (hydroacridine), anthracene (methylanthra-
cene), arsenic and its compounds, etc., have all been accused, there is no
doubt certain external conditions also have great importance in the causation of
the more serious skin affections, as, e.g., insufficient cleanliness of the ma-
chines as well as that of the workers; fair and red-haired workpeople are
more affected than dark. Workers newly employed are regularly attacked,
but later acclimatisation seems to establish itself.

Bridge is of opinion that the injurious action of this substance is due to the
heavy mineral oil; others lay the blame on the traces of arsenic introduced
into the product by treatment with sulphuric acid, always containing ar-
nenic as an impurity (Norman Tate); others again are of opinion that the
sulpho-acids or ammonium sulphate
remaining in the paraffin after refining
are at fault.

The solvents of the fats contained in
the crude oil, the crude tar and paraffin are also the cause of a general action
because when they get into the circulation they affect the cellular
chemical combination by dissolving the lecithins and other lipoids. Their
action is the more intense as their solubility in fats is greater and their
solubility in water is less. The lesions are, further, the more marked the
richer the organ is in fats. Thus it is that in the central nervous system
the effects are most pronounced (see articles "Benzene", "Petroleum",
"Shale Oil Industry", and "Tumours of Occupational Origin (Occupational
Cancer)").

STATISTICS

The data as to the frequency of occupu-
tional affections due to paraffin are not
numerous. The cutaneous lesions are cer-
tainly the most frequent and the most severe.

In Austria, the inspectors of factories
describe 29 cases of "itch" among 63 paraffin workers; in 1913, several cases
were reported from a pasteboard factory, and
7 more or less severe during the war
(1914-1918). An enquiry made in the centre
of the crude oil industry in Galicia revealed
13 cases of cancer, almost all localised
in the scrotum, and operated upon
in a space of 8-10 years. Ullmann collected
particulars of 13 cases of cancer of the
skin in 10 years (1900-1912) as a result of a
questionnaire addressed to 20 paraffin
works.

In France, Barres and Courtois Suffit
in 1903 described pustules, ulceration and
especially papillomata of the skin among
the cleaners of boilers and tanks containing
the residues of the final refining of
petroleum. In 1892 Derville and Guermonprez described cases of warts among
petroleum refiners.

In Germany, Eckhardt (Diss. Halle, 1886)
reported 4 cases of paraffin cancer, Michel-
sohn (Berlin, 1888) and Voigt (Berlin, 1892)
published a dissertation on the epidemic
which were studied also by Liebe in 1893.
Gawrowsky (Diss. Halle, 1904) examined
the subject anew in relation to some cases
observed by himself. Inspectors of facetries report annually cases of severe
injury to the skin more or less due to
paraffin.

In Great Britain, Ogston (1871), of Edin-
burgh, and Bell (1895) reported the first
cases of paraffin cancer; Bellat (1878) de-
scribed a case of scrotal epitheliomata. Kirk
studied others in 1903. Legge (1922) in the
Medical Inspectors' Report gives the statistics for the years 1911 to 1919: 12 cases
of epitheliomatous tumours due to paraffin.
In 1920 notification of epitheliomatous
ulceration contracted in a factory or
workshop became obligatory on all med-
ical practitioners, and since that year they
numbered 3 in 1920, 6 in 1921, 5 (1 death)
in 1922, 6 in 1923, 2 (1) in 1924, 4 in 1925,
2 in 1926, 4 in 1927, 2 (1) in 1928, 4 in 1929,
0 in 1930, 2 in 1931 and 1 in 1932. Cases
of simple dermatitis due to paraffin were
much more numerous: 98 from 1927 to
1930.

According to age the cases cited by
Legge were as follows: one aged from
31 to 40 years, a second from 41 to 50, and
a third from 51 to 60: three others were
over 60 years of age. They had been em-
ployed from 15 to 20 years in 1 case, 20 to
30 in 3 cases, and 30 to 40 in 2. The
lesions were localised in the scrotum in 2,
on the forearm in 4, the neck in 1, and
the eyelid in 1.

A. Scott, who as a certifying surgeon has
been able to follow the cases closely for several years among the thousands of
workmen in the oil refineries of Scotland,
has collected records of 65 cases, of which 19
were engaged in the crude paraffin sec-
ton employing in all 200 men (a morbidity
of about 5 per cent. per annum).
Only 3 were less than 40 years of age,
23 from 51 to 60; 13 from 41 to 50; the other
26 were over 60. While among the 19
paraffin workers the lesion was situated in
63 per cent. of the cases on the hands and
forearms, in 16 per cent. on the face,
and in 16 per cent. on the scrotum, among
the 46 cases set up by petroleum the lesion
affected the scrotum in 61 per cent., in 20
per cent. the arms and hands, and in 15
per cent. the face. Duration of employ-
ment in all cases had been long. Of the 19
paraffin workers 12 had worked from 18 to
39 years. Only a small number of the
lesions become malignant and, according
to Scott, the personal factor plays an
important part when they do.

In 1913 W. Walker described three cases of
paraffin tumours situated on the back
of the foot, on the scrotum and on the
back of the hand (necessitating ampu-
tation of the arm); Brown described 5 out of 10 workmen as suffering from severe ulcerations, etc., and Wilson noted several cases of warts, etc., in paraffin refineries. Several cases, moreover, cropped up in the period 1914-1918 in the Scottish shale mines, and in 1919 a voluntary agreement was come to between the employers, the employed, and representatives of the Factory Department with a view to improving conditions of work at the paraffin refineries. Walker's enquiry on paraffin factories and petrol refineries was carried out in 1919. From that year dates also the quarterly medical examination of those employed in the green sheds (refinery).

**Symptoms**

The term, now classical, of "paraffin cancer" comprises quite a number of skin lesions, such as comedones, folliculitis, pustules, simple erythema, papular erythema, etc.

These lesions, which affect about 50 per cent. of the workmen engaged in the refineries, commence some weeks or months after first employment; they last all the time work continues and disappear (at least the less chronic forms) a short time after giving up work.

The different kinds of dermatitis (papular, pustular, erythematous, etc.) are due to direct contact with some chemical substance which by giving rise to warts and cellular indurations acts as a predisposing agent.

1. Dermatosis. — This presents several types of which one or more may be found on the same individual. The skin is the seat of intolerable itching; neglect leads to a chronic condition with rhagades and hyperkeratosis. Sometimes the skin shows a brownish-black pigmentation and diffuse thickenings; sometimes an eruption of pimples on the face, on the extremities or on the scrotum. The number of the affections varies with different oils and the technical manner in which the processes are effected.

(a) Comedones: these occur on the uncovered parts of the skin; are purely mechanical in origin, the paraffin substances obstructing the sebaceous glands, or, by thickening of the superficial layers of the epidermis, resulting in blocking of the sweat glands. They are of little importance from the point of view of the production of malignant lesions.

(b) Folliculitis, perifolliculitis, follicular dermatitis: this is the commonest of the lesions among paraffin workers (40-50 per cent. are affected) in the first 10 to 12 days of work. As a result of a moderate inflammatory reaction, the hairs and hair follicles are destroyed, and the skin is red with black projections without fluid contents and without itching. This form has a typical distribution occupying the forearm (ulnar surface), wrist and back of the hand; in 20 per cent. of the cases the legs are also affected.

(c) Pustular dermatitis: two types occur, the one characterised by numerous small pustules on the anterior surface of the body and its extremities, the other by a pustular eruption due to the typical papule, which is the commonest form of the occupational eruption.

(d) Papular dermatitis or papular erythema: consists in an eruption of small round elevations of reddish colour, varying in size from that of a small grain of pepper to that of a small pea. It occurs in some 40-50 per cent. of the cases of dermatosis.

(e) Simple erythema: this is a moderate hyperaemia in which the erythema is uniformly distributed over the forearm.

(f) Erythematous dermatitis: a subacute or chronic type due to the irritating action of a semi-refined paraffin on the tissues of the skin for a sufficiently long period (7 to 8 years). It represents an extension of the erythema in which the congestion has gradually passed into a state of chronic inflammation of the different layers of the epidermis and of the "cutis vera", followed by thickening and, in the most advanced cases, by a partial or complete destruction of the skin of the parts affected. Tendency to the formation of small, flat, squamous, oval or circular warts is also common. Once this stage has been reached, the formation of characteristic epithelial overgrowths occur, sometimes long after the workman has ceased to have any contact with irritating paraffin substances.

2. Epithelioma. — Among workers over 40 years of age and with duration of employment of more than 20 years, epithelial growths may develop from epithelial layers of the warts and papules, followed by ulceration and necrosis. In general, only one epithelial ulcer develops in an individual, but there are instances in which several, one after the other, have occurred in the same person. These tumours usually start from a hard wart or papule and co-exist with an advanced condition of erythematous dermatitis. The clinical picture is
that of an epithelioma developing slowly in the midst of a chronic dermatitis, with numerous warts or indurated papules of papillomatous nature, one of which has taken on malignancy. The colour of the skin of the face, arms and chest becomes yellower or brownish ; the sclerotics are similarly yellow ; the lesion is situated commonly on the back of the hand and forearm; the scrotum is also not unfrequently the seat of growths, which may be explained by the delicacy of the skin in that situation, by constant contact with dirty clothes, friction, warmth, and eventually by soiling with contaminated fingers during micturition. At the external or internal angle of the eye, the lesion assumes the form of a rodent ulcer.

The clinical development of the cancer is relatively benign for a long time, and is finally that metastases with severe generalised symptoms occur. (Cachexia). Excision may lead to curing the individual, but metastases and recurrences elsewhere have occurred after the operative treatment as frequently as at the site of the scar. If the workman gives up his employment in time a cure or remission is possible; if he continues his work, new growths with their sequelae develop. All changes in the skin of these workers should be watched, especially because of the difficulty of diagnosis as to whether the tumour is cancerous or not when situated on the scrotum. (See article "Tumours of Occupational Origin (Occupational Cancer").)

Numerous observations have been made on the cutaneous lesions set up by grease and impure crude oil, especially during the war when those engaged in engineering works suffered in every country. Lack of pure mineral oil on the one hand, and of fatty tar oils on the other, led to the use of the products of distillation of lignite and naphtha which are rich in creosote and in unsaturated aliphatic hydrocarbons, and, no doubt, on technical grounds, contain little paraffin. (See article "Petroleum").

Attention should also be drawn to the relatively high frequency of burns among the refiners.

**General disturbances.** — Inhalation of volatile hydrocarbons contained in crude oil and paraffin, and absorption of them through healthy or unhealthy skin, give rise to affections of a general nature, the picture of which varies with the nature, origin, degree of purity of the product, and its contents in hydrocarbons boiling at high or low temperatures. Finally, it is of importance to know whether it is a question of air very rich in the concentrated vapour and insufficiently supplied with oxygen (as e.g. in air in boilers, tanks, vats, small workshops).

In these cases rapid loss of consciousness and even death occur unless the victims are very rapidly brought into the open air. Inhalation of very small quantities of the gas produces a condition resembling that of a drunken man, with headache and vertigo which disappear again when the patient is brought into the open air.

Continuous inhalation of certain quantities of the gas (with sufficient oxygen present) induces a remarkable pathological condition characterised by debility, somnolence, heaviness in the head, buzzing in the ears; the clinical picture is similar to that of marked alcoholic intoxication, somnolence lasting for whole days, sometimes with loss of consciousness, amnesia, etc. In other cases there is a state of excitement progressing to a maniacal condition with delirium, hallucinations, muscular tremor, clonic spasms; sometimes neuritis, paraesthesia, difficult deglutition and speech, shooting pains in the neck and chest, fall in the body temperature especially in the peripheral parts, with cyanosis and sensation of cold, diminution in the respiratory rate and pulse. Loss of appetite, erections, vomiting and diarrhoea have been described. The conjunctiva becomes the seat of an irritation more or less severe with affection of the sight; the respiratory tract is also irritated (cough, crises of suffocation, bronchitis, etc.). Analogous symptoms have been observed from the use of lubricating oils, as a result of repeated inhalation of gas over a long period (chronic action).

**Diagnosis**

This turns on the history of the case, that is, on knowledge of the kind of work. In many cases the intense odour of the clothes and skin of the patient give the clue, a smell which persists even after repeated bathing. The stools, urine, and expired air also smell of petroleum for a long time. The varying clinical picture of the different skin lesions complicates the diagnosis. For paraffin workers particularly they are — comedones, epithelial proliferations, and pigmentation.

The general symptoms affect mainly the central nervous system; somnolence, cold extremities, and muscular contractions are those on which, together with the history, reliance is to be placed.
HYGIENE

First aid. — Cases of poisoning call for immediate removal from the place of work (the atmosphere containing the gas) to fresh air, and if necessary oxygen inhalation, baths, hot applications, stimulants (see article "First Aid"). Treatment of the skin affections follows that of the customary dermatological therapy. Severe cases call for suspension from work until a cure is effected. Growths must be promptly removed surgically.

Technical preventive measures are directed to substitution of machinery for hand labour, especially of closed and automatic apparatus. As the work at the filter presses exposes to greatest risk it would be well if some other process could replace it. Tanks which have contained petroleum, tank wagons and other closed receptacles should not be entered until they have been thoroughly ventilated; if this has not been done then the wearing of breathing apparatus is necessary, with some person keeping watch the while from the outside.

Further means of personal hygiene against contamination should be considered. The suggestion of protecting the face by means of a cap with large flaps and a covering over the neck has been made; and also the provision of large and impermeable aprons, wellington boots, thick gloves, zinc ointment, etc., for slight scratches has been suggested. Other measures should be observed: daily examination of the skin (especially of the exposed parts) of the workmen by trained medical men, instruction of the workmen as to precautions to be taken. Cloakrooms, washing and bathing accommodation, and arrangements to permit of change of overalls impregnated with oil should be in charge of a responsible person.

Cleaning the hands with benzine or sawdust impregnated with benzine is important and much resorted to; it, however, injures the skin as it removes the natural grease and makes it crack. Further, the skin of many persons is sensitive to benzine and reacts with symptoms of irritation. Rubbing the soiled skin after work is over with dry sawdust is useful, or washing the skin very rapidly in benzine and then in soap and water, followed by smearing slightly with lanoline and glycerine. It is essential that baths and means for cleanliness should be constantly available. Time devoted to cleansing purposes should be included in the hours of work. Working clothes and underclothing should be changed for homegoing ones after washing. Douche baths and rest-rooms should be installed. The ambulance room should keep in reserve a cylinder of oxygen, breathing apparatus, bandages, dressings for burns, etc.

LEGISLATION

No special Regulations are in force for petroleum refineries. In Great Britain, however, in 1919 a voluntary periodic medical examination of the persons employed in the green sheds (refinery) was arranged for with provisions including, among others, requirements on the following lines:

1. Paraffin workers to be provided with suitable working clothes, overalls or over-all suits. A complete suit to be provided once in every twelve months. In addition, suitable protective clothing to be provided for all scale (refinery) workers.

2. Shower or douche baths, with hot and cold water, suitable and sufficient washing accommodation with hot and cold water, and a sufficient supply of soap and towels for all the above workers. Suitable accommodation for clothing, with adequate arrangements for drying clothing if wet or damp. Messrooms, cloakrooms, bath and washing accommodation to be placed under the charge of a responsible person, and to be kept clean and adequately heated when necessary.

3. All workers in the green shed (refinery) department to be examined once at least in each quarter by the certifying factory surgeon, with power to suspend and to supervise the ambulance equipment and treatment.

4. The occupier to provide and maintain in good order an ambulance room. It shall contain among other things: (a) means for treating skin lesions (sterilised dressings, ointment, etc.); (b) a stretcher and breathing apparatus.

In Argentina women are excluded from work on distillation of tur products (paraffin, etc.).

Before the war the Austrian (Galician) Factory Inspectorate had arranged a monthly medical examination of all paraffin workers and the keeping of a register of such examinations. No data as to its application are available.

Every skin lesion, cancer, and ulceration of the cornea or conjunctivitis in persons employed in refining petroleum or tar or their derivatives must be notified in the Netherlands.

Epitheliomatosous ulceration of the skin or ulceration of the corneal surface of the eye has been made notifiable in Great Britain and Poland and is compensated as an industrial accident disease in Austria, Germany, Great Britain and the United States in the following states: Minnesota, New York and Ohio.

Compensation is afforded in Germany for cancerous dermatitis.
PARANITRANILINE

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Prof. F. Kölsch
(Munich).

Paranitraniline

French: Paranthraniline. — German: Para-
nitranilin. — Italian and Spanish: Para-
nitranilina.

P.-nitraniline \([C, H, NH, NO_2 (1 : 4)]\) is
prepared by treating, at a temperature of
165° to 170° C., the p-chloronitrobenzene
with an excess of concentrated ammonia;
it is filtered, washed and dried. Starting
from acetanilide there is obtained after
nitration, at a temperature not exceeding
40-50° C., a mass which is then filtered.
The precipitate obtained is washed, com-
pressed, redistilled, with water, heated, and
neutralised by soda. In this way the impuri-
ties of the \(o\)-nitraniline are dissolu-
vved and there remains fairly pure
p-nitro-acetanilide which is collected on the
filter. The mass is taken up again with
water and caustic soda and brought to
boiling point. After being allowed to
stand, the mother liquors are drawn off
by syphon and the mixture is taken up
again with slightly alkaline boiling water.
It is then cooled, filtered, washed, dried,
and finally pulverised.

Pure p-nitraniline occurs in the form
of yellow crystals, which melt at 174° C.
It is very slightly soluble in water, slightly
soluble in alcohol and soluble in ether.
It is used in the dyestuffs industry.

Amongst the other nitro-derivatives of
aniline should be mentioned: m.-nitra-
tiline \([C, H, NH, NO_2 (1 : 3)]\) obtained
by reduction of \(m\)-dinitrobenzene. It takes
the form of inodorous yellow crystals
with a melting point of 114° C. It is soluble
in organic solvents and very slightly
soluble in water. It is used in the pre-
paration of alizerine yellow, dinetranil-
line, orange, etc.

The dinitranilines: only the isomere: 1:2:4
is of practical importance. It is obtained
by starting from 1:2:4 dinitro-chloroben-
zeine and concentrated ammonia. It is
employed in the preparation of violet
colouring matters for wool, fast red col-
ers, etc.

For tetranitraniline and tetranitromethyl-
aniline, see article "Explosives" § 3:
Nitromines.

TOXIC ACTION

The p-nitraniline is the most toxic
of the nitrated products of aniline.
Animal experiment has demonstrated
that it can be absorbed by the gen-
istive tract without serious harm
when the stomach is full. Doses of
0.3 to 0.5 grm. fed to cats under these
conditions have merely caused the
temporary presence of methaemoglobin
in the blood. On the contrary, in the
case of fasting animals, 0.2 to 0.3 grm.
may set up serious symptoms (tremb-
ling, paralytic and coma) followed
by death. Small doses (0.1 grm.)
distributed to a cat daily during
one month only caused very slight
troubles. Absorption by way of the
skin must be on a large scale to cause
fatal poisoning (Lehmann). Accord-
ing to Fischer, the paranitraniline
seems to possess a cumulative toxic
action, and in cases of resorption by
the skin the sub-cutaneous tissues act
as a reservoir. The toxic action is
exerted on the blood (formation of
methaemoglobin) and on the nervous
system (central paralysis of the heart).
Ischuria, haemoglobin and bilirubinuria
have also been reported (Bachfeld,
Lehmann, Lewin).

The toxic action of \(m\)-nitraniline
affects animals in the following de-
creasing order: dogs, cats, guinea pigs,
rabbits. A dog weighing 4 kg. died
in four hours as the result of an in-
tra-peritoneal injection of 15 cc. of
3.5 per cent. solution of \(m\)-nitraniline
in olive oil (or 0.07 grm. per kg.). Death
occurred after acute dyspnoea and con-
vulsions. At the autopsy the usual
lesions of asphyxia were found, but no
haemoglobin on spectroscopic examina-
tion. In the case of rabbits, poison-
ing which is not fatal may cause seri-
ous secondary anaemia. The urine of various poisoned animals showed a change in coloration (dark red brown), and there were found in it traces of albumen and sometimes a few red cells. There was never evidence of methaemoglobin. A second injection always caused less accentuated modifications whilst fatal doses set up anuria.

**Pathology**

In 1898, Bachfeld reported 9 cases, 4 of which were serious, of poisoning by p.-nitraniline. One case of aniline poisoning recorded in 1899 was attributed to inhalation of nitraniline dust (Rambousek). One case of an unusual disease resulting in death which occurred in 1909 in a nitraniline factory revived the question of the toxic action of this product. A worker aged thirty on arriving home one evening experienced a violent indisposition accompanied by a choking sensation, insatiable thirst, and a reddish violet coloration of the face. These symptoms continued into the night, but the next day the worker resumed his work. The foreman was only able to note the extreme pallor of his face, for, some seconds later, the patient died suddenly.

The autopsy revealed alteration of the coronary arteries, the presence of blood clots and, on spectroscopic examination of the blood, methaemoglobin. The victim had handled a considerable quantity of nitraniline either while sweeping dust which had fallen from receptacles being filled or while centrifuging the toxic product for hours at a time (Lewin).

Since then several cases of poisoning by p.-nitraniline have been reported: in Bavaria (1913) a case in which the symptoms recalled those of aniline poisoning and in Austria a case affecting a worker in a factory for printing cloth. In 1919 two cases occurred in the State of Hesse. In Great Britain, Henry reported in 1921 4 cases of poisoning affecting workers and one chemist engaged in sitting the product in question. In one of the cases the poisoning took a serious form, characterised by attacks of headache, nausea, vomiting, vertigo and obnubilation. The face and lips of the patient were yellowish-grey and the ears were cyanosed; he suffered from respiratory trouble, oppression with pain in the chest and cold in the extremities. In 1922, a fatal case occurred in Germany affecting a worker who had received splashes of the product while plunging an iron bar into a crust of p.-nitraniline under which there was water at a temperature of 95° C. There has been compulsory notification of cases of aniline poisoning in Great Britain since 1925; during the period 1926-1928 20 cases of poisoning due to p.-nitraniline dust were recorded.

Hamilton records the case of a worker of twenty-seven years of age who had been engaged for twelve days in the p.-nitraniline department. He had been poisoned by inhaling the product in powdered form which was accidentally liberated by the apparatus. He was sent to have a douche bathing and subsequently to the hospital, where twenty minutes later he fell into a state of unconsciousness and died in spite of the treatment applied. Death occurred two and a half hours after the accident.

An enquiry undertaken in 1928 by Jablokov, Sapojnikoff and Leites amongst workers in a Russian nitraniline factory revealed methaemoglobininaemia in 11 cases out of a total of 31 workers. The authors confirm the observations made by other experts and consider that acute poisoning by p.-nitraniline presents the same clinical symptoms as aniline poisoning; that rapid inhalation of p.-nitraniline exerts, in the first place, an action on the central nervous system and on the blood, in connection with which latter slight haemolysis is noted and the presence of a small quantity of methaemoglobin; that the nervous symptoms cannot be attributed to the formation of methaemoglobin in the blood; that the pallor of the skin finds its explanation not in the diminution of haemoglobin but is due to vascular spasm produced by the action of the p.-nitraniline on the vasomotor centres; that the symptoms of chronic poisoning consist in cephalalgia, pallor, vertigo, hypothyemia, tendencies to fatigue, circulatory derangement, inflammation of the liver, increased perspiration and slightly marked alteration of the blood count.

Finally, there is the irritant action on the eyes and the skin of workers exposed to powdered p.-nitraniline (Prosse-White).

Individual tolerance is rather variable and even a certain degree of immunity has been recognised among some workers in contact with this product.

Caubert (1904) had reported many cases of poisoning amongst workers engaged in dyeing articles red with p.-nitraniline. This product, wrongly designated in certain districts of France as "Russian red", was chiefly employed in dyeing thread intended for weaving cotton goods. There had
formerly been used "Turkey red" (alizarine) derived from madder root and in its turn replaced by artificial alizarine. The skin of cotton, mordanted by means of a solution containing β-naphotl and caustic soda, was subsequently wrung out, dried and immersed with a diazo solution, in which there occurs double decomposition between the β-naphotlate of soda of the fibre and the diazo chloride of the solution. The diazo dye of a beautiful red is then formed and fixed on the fibre. The solution for diazotization is prepared with p.-nitramine and hydrochloric acid.

Workers who had their hands constantly in the solutions (alkaline and diazo), who were in the habit of working bent over the vats, from which slight clouds of vapour were given off, and who wrung out the skeins with bare hands, complained of headaches, digestive derangement and especially a fairly serious form of eczema known as "purpurism". Localised on the hands, forearms and at times on the chest, this affection commenced with a slight swelling of the skin followed by the outbreak of numerous red spots accompanied by itching. If the worker left off work it healed at the end of four or five days; if not, the spots turned into pimples which finally dried up. Healing then took four or five weeks.

Caubert considers that the action of each of the two baths played a part in bringing about this effect and that neither would have sufficed to do so by itself. The injury was one which specially affected workers engaged in dyeing red with p.-nitramine. The use of gloves rapidly eliminated the "purpurism" and the introduction of a machine effecting mechanical impregnation and wringing of the cotton soon rendered all the operations in question quite harmless.

As regards human pathology due to m.-nitramine, Hamilton has reported a case of a young worker who had cleaned out a vat which had contained the product in question. Very shortly afterwards he complained of frontal headache, suffered from attacks of vomiting and lost consciousness. The hospital to which he was taken noted acceleration of the pulse and intense cyanosis, the lips and mucous membranes being almost black. Another case was reported by the New York Department of Labour of a worker who had cleaned out a receptacle which had contained m.-nitramine. The victim complained first of all of stomach trouble and nausea; the next day, shortly after resuming work, he was found lying on the ground uncon-
The addition of soda sulphite is said to attenuate the irritant effects of the substance. It is also used for dyeing hair and furs (ursol) and as a photographic developer with sulphites and alkaline liquids.

Certain organic substances used in the direct production of brown or black tints on hair or fur are known commercially under the name of "ursol".

The colouring medium is generally got by oxidation. Peroxide of hydrogen is at times used as oxidising agent, or chromates (bichromate of potassium) or quinone.

Dyeing may be effected directly or by means of mordants (iron, chrome, copper). P.-phenylenediamine is known commercially under the name of "ursol D", whilst hydrochloride of p.-aminophenol, etc., is designated "ursol P". In the different countries, however, these colouring agents are generally known under fancy names.

**TOXIC ACTION**

As regards the minimum fatal dose, these compounds may be classified in accordance with the experimental research effected by Hanzlik (1923), in the following descending order: dimethyl- and diethyl-p.-phenylenediamine; p.-phenylen diamine; m.-phenylen diamine.

The first two of the above are, in a basic form, capable of absorption by the intact skin on account of their volatility and their liposoluble property. Their fumes are also toxic. Poisoning is characterised by acute symptoms with fatal evolution. Locally these two substances exercise an irritant action (dermatitis) which is not caused by their salts.

The p.- and m.-phenylen diamine are very slightly or slightly irritant, but their effects vary in accordance with the conditions under which the experiment is carried out. They both give rise to identical symptoms: cardiac and respiratory excitement, fall in the temperature, trembling, convulsions, coma, death.

Medical experts engaged in investigating injuries due to ursol have undertaken research with a view to determining the pathogenesis of the poisoning. Prosser White has been able to establish the fact that after the second day the cutaneous region in permanent contact with a fur dyed with a solution of p.-phenylenediamine showed considerable irritation, which after a lapse of less than four days developed into papulæ. As a counter-test, a high-class dyed skin applied under the same conditions to the skin gave rise to no trouble of any kind. Experiments of the same nature were engaged in by Semon, who remarked the outbreak of a form of dermatitis after the first twenty-four hours. The fur used showed a slight acid reaction and left traces of a reddish colour on paper. No oxalates, chlorides or chromates were found, but small traces of arsenic. A systematic study of the toxic action of the products in question, namely, of those that Hanzlik has demonstrated that p-phenylenediamine in the dry state or in a 10 per cent. alcoholic solution was only relatively slightly absorbable and merely caused slight irritation of the skin. In solution with water, on the other hand, its harmful action was considerable and almost as intense as that of quinone. Hanzlik was of the opinion that these compounds are definitely toxic and that asthma and respiratory troubles noted amongst furriers are due particularly to direct irritation of the smooth muscular system of the bronchi rather than to anaphylactic action.

According to Mayer, 1929, individual reaction is said to give rise to asthma or eczema in accordance with the point at which the injury occurs. He therefore supports the opinion of von Criege, of Curschmann and those medical experts who ascribe these injuries to an allergic phenomenon connected with ursol or its oxidation products (quinonedi amines), which holds good of all bodies having a quinonic structure. A similar opinion has been expressed by Buschke and Ollendorf, R. Ledermann and R. L. Mayer in regard to forms of dermatitis. Prosser White considers that in this case it is a question of irritant action caused by products of oxidation. There has, however, been noted a special effect on the part of certain p-phenylen diaminic derivatives to the exclusion of certain others.

Observations relative to dangers connected with ursol are very numerous. An enquiry into the subject undertaken in December 1928 at Leipzig has enabled Mayer and Förster to study troubles caused by use of p-phenylen diamine and its derivatives in the case of 181 workers engaged in the fur industry. They found that out of 111 workers suffering from asthma or eczema of occupational origin 78 regarded ursol as the cause of their troubles, 21 ascribed symptoms to ursol in accordance with the diagnosis of their doctor; whilst the remaining workers attributed their illness to different substances: chlorine, ammonia, dust, etc. The illnesses noted were distributed as follows: eczema, 50 cases (45.0 per cent.); asthma, 43 cases.
PARA-PHENYLENDIAMINE

(38.7 per cent.); asthma and eczema combined, 18 cases (16.2 per cent.).

In 49 of these cases there was noted hypersensibility to the effects of ursol. This reaction was encountered in 46 per cent. of those suffering from eczema, in 30.2 of the asthmatic subjects and in 72.2 of the patients suffering from both diseases.

PATHOLOGY

Since the first industrial utilisation of ursol pathological disturbances have been noted in connection therewith (forms of dermatitis, Carozzi; asthma, von Criegern), especially amongst workers in the fur industry. It has even been found that persons wearing furs dyed with ursol suffer from more or less serious effects and, finally, serious cases have been met with amongst persons whose hair was dyed with dyes having an ursol basis. Injuries caused at the outset amongst workers in the fur trade were fairly numerous and Lehmann has reported in one single year for Leipzig 187 cases of poisoning.

According to the observations of Prosser White, cutaneous troubles are encountered chiefly amongst the workers who handle liquid colouring agents. The quinonic fumes which are liberated at the moment of oxidation in production of black colours have, however, an irritant action on the mucous membrane of the nose and eyes. The eruption affects generally the face (corners of the mouth, pupils, nostrils), the back of the neck, the fore-arms and particularly the dorsal region. The parts of the body protected by clothing are not affected and likewise the anterior part of the arm escapes. The hands are strongly discoloured with a blackish brown colouring. Localisation is explained by the fact that certain cutaneous regions and damp mucous membranes favour adhesion of dust particles. Cutaneous lesions which are small and superficial at the outset take the form of small round papulae surrounded by a red zone which becomes partly covered with yellow crusts and may even undergo ulceration.

Prosser White remarks that none of the patients examined by him showed any tendency to seborrhoea or to soda- tion which would render the skin more liable to the development of dermatosis.

Besides 4 cases of eczema, examination of 25 workers in the "Proletarski Troud" Fur-Dyeing Works, of Moscow, revealed 12 cases of hypertrophic rhinitis; pharyngitis in the case of 9 workers; and chronic bronchitis in the case of 6 other workers; 9 were subject to violent fits of coughing, which however ceased as soon as they left off work. The hands of the workers in question were quite black. The workers complained of difficulty of respiration, spasms of the throat with a sensation of dryness and a special taste in the mouth, watering of the eyes, etc. The furs which had given rise to these symptoms in the case of the workers were also responsible for setting up dermatitis amongst people who wore them later and at times customers returned their purchases, lodging complaints and demanding damage.

In France, Thibierge and Lacassagne engaged in a study of eczematous dermatitis due to the wearing of dyed furs (1926).

Gougerot, Barthélemy and Cohen published in 1930 particulars of a case of dermatitis affecting the face and hands of a woman who had worked for six months in a rabbit skin factory.

Atmospheric humidity, perspiration, the more or less careful methods employed for dyeing, washing and freeing from grease the furs in question, all play a part in the development of these forms of dermatitis. It is necessary to consider in conjunction with these the role played by the constitution, the frequent incidence of endocrine troubles in the case of these patients being well known (Babalian).

The other typical symptom represented by asthma is attributed to the use of certain products of the aromatic series (p-phenylenediamine; o- and p-amino-phenol; p-aminophenylamine; p-amidopara-nitratiniline; p-aminophenylamine; p-totuylendiamine, etc.).

The troubles caused by colouring matters in the French industry for the production of cheap furs — generally rabbit — have been described in 1930 by Babalian and Reitlinger. These colouring agents were used with a view to imparting to the fur the appearance of expensive furs.

Ursol disease would appear, according to the experts, not to consist of an allergic reaction but of a purely local reaction of the skin and respiratory passages.

The cutaneous reactions which characterise them are of the eczematous or prurigo type. Those affecting the respiratory apparatus are grouped under the name of ursol asthma and involve a series of asthmatic troubles of the upper and lower respiratory
passages. These reactions occur preferably amongst subjects showing predisposition following the slightest irritation.

General poisoning due to p-phenylenendiamine has been observed by H. W. Nott in the case of a hairdresser who for three years had utilised this product in dyeing hair. He suffered from sudden fits of illness characterised by the following symptoms: palpitation, feeling of weakness and fear of immediate death, at times followed by loss of consciousness, greyish cyanosis of the face, anxious expression, moisture of the eyes, swollen conjunctivae, oedema of the eyelids, gums and tongue.

DETECTION

With a view to rapid research for p-phenylenendiamine in a liquid, it should be alkalised where necessary, extracted with ether, decanted, and the ether solution taken up with acidulated water (hydrochloric acid). It should then be shaken, decanted afresh, and the phenylendiamine detected in the watery solution by means of perchloride of iron.

Shitkowa (1929) has suggested two methods of detecting with adequate precision small quantities of p-phenylenendiamine. In the use of the titrimetric method he determined the presence of p-phenylenendiamine by oxidation by means of hypochlorite of soda; in the case of the colorimetric method he utilised an indamine reaction (FeCl3 and aniline), which permits of titration of 0.002 mg. of p-phenylenendiamine. This product can be extracted from dust or hair by means of hot water.

Shitkowa again has been able in this manner to titrate 0.004 per cent. in dust which contaminated the working benches and 0.006 mg. in dust contained in a litre of air in a Russian factory. The product in question was non-oxidised p-phenylenendiamine.

In another Russian factory for fur-dyeing Schliffmann (1929) found 0.0029 to 0.0014 mg. per litre in air of a Russian factory. These反应s were, however, without any means of ventilation.

HYGIENE

The aqueous solutions of phenylenendiamine and toluylenendiamine are highly toxic. Dilute solutions seem to exercise an action on the skin. There should therefore be taken, in regard to these solutions, precautions similar to those prescribed for the products themselves.

The phenylenendiamines and toluylendiamines are less volatile than aniline. Diluted, cold aqueous solutions containing less than 10 per cent. of these products may be stored, transported and decanted in apparatus or receptacles which are not hermetically closed. Practice has proved that this procedure is without harmful consequences.

For measures of general and special hygiene, see articles "Aniline", "Chemical Trades" and "Nitro and Amido Derivatives".

As regards the protection of workers engaged in dyeing with colouring media with a phenylenendiamine basis, rubber gloves, adequate means for washing the hands and headgear should be provided. Workers should not have beards or moustaches.

Increasing use should be made of substitutes for colouring media with a phenylenendiamine basis. The processes of fur-dyeing should be closely supervised when the products in question are manipulated. There have been recommended the use of the most dilute solutions possible and the restriction of the utilisation of the mordant until the very moment at which the furs are dipped. Coloured skins should be thoroughly washed in running water, dried, and thoroughly beaten for several hours in a revolving drum containing sawdust or some other similar substance.

LEGISLATION

See articles "Aniline", "Chemical Trades" and "Nitro and Amido Derivatives".

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Parasites


Under the name of parasitic diseases are designated those disease forms caused by animal parasites either Protozoa or Metazoa (worms, acari, insects).

Like agents of infection, parasites under special working conditions may give rise to occupational diseases, certain of which are, however, more frequent in certain tropical countries.

Reference should be made to the article "Infectious Diseases" for general considerations. Here it will suffice to recall that, besides the direct effect which they exercise, parasites also play a part in the transmission of certain infectious diseases.

To avoid passing in review the whole human parasitology, this article will be confined to enumerating the parasitic diseases reported by various authors as having been at times of occupational origin, giving a very short account of these since fuller details will be found in treatises on special pathology. (See also articles "Ankylostomiasis", "Anguillulosis" and "Infectious Diseases", in which certain parasitic affections have already been dealt with.)

ASCARIASIS. — This disease is due to a nematode worm (Nematelminia), the *Ascaris lumbricoides*, an intestinal parasite peculiar to man which transmits infection by accidental ingestion of eggs. Workers digging the soil, engaged in cultivation, and miners are particularly exposed. The presence of merely one infected and dirty individual disregarding all hygienic precautions is sufficient to give rise to veritable epidemics of ascariasis (Brumpt).

BALANTIDIOSIS (Balantidium dysentery). — A disease due to *Balantidium coli*, an infusorian parasite of the intestine, the host in general being the pig. In numerous cases persons in contact with this animal become contaminated (pig-farm attendants, workers in pork butchers' shops). The disease is likely to be confused, in regard to its symptomology, with amoebian dysentery.

BOTHRIOCEPHALOSIS. — Disease caused by the "*Botrichcephalus latus*" a broad tape-worm, the larvae of which are often found in lake fish; and are considered by some authorities as an occupational disease of fishermen (Quarelli), who become contaminated during manipulation (gutting fish) or by ingestion.

CYSTICERCUS DISEASE. — An affection produced by the larvae (*Cysticercus cellulosae*) of a tape-worm (*Platyhelminia*), the *Taenia Solium*, the usual parasite of the pig, also known as "hyatid" or "pork measles". Certain social conditions may favour contact with faecal matter or soiled objects (rag-sorters) or infestation by *T. Solium* (butchers, pork butchers). Man becomes infested by absorption of the eggs in carrying these to the mouth on soiled hands. In the stomach the eggs give birth to embryos which are thereafter distributed through the whole circulation of the system and become the centre of cysts which give rise to varying symptoms according to their localisation (brain, eye, muscles, cellular tissue, heart, etc.).

DIPYLIUMASIS. — According to Guer-rini, this is the only infection by *Cestoda* which may assume an occupational character. The disease is due to the *Dipylium Caninum*, a parasitic worm peculiar to the dog and at times the cat. This disease affects especially those in contact with the animals in question (keepers, trainers, dog-shearers, poachers, dog-catchers).

The most usual intermediate host is the dog flea (*Ctenocephalus Canis*) and even the human flea (*Pulex irritans*) in its adult state. Man becomes infested by caressing animals or through swallowing the parasitic flea.

INTESTINAL DISTOMATOSIS. — Affection due to *Fasciolopsis buski*, a fluke which chiefly affects agricultural populations. The disease is characterised by a more or less lengthy latent period (sometimes several years), followed by diarrhoea (yellowish fetid excreta), which may last several months, and then by a terminal period of oedema of the abdomen and lower limbs. Prognosis is serious only in advanced cases complicated by oedema and intense anaemia.

PULMONARY DISTOMATOSIS. — See Paragonimiasis.

ECHINOCOCUS DISEASE. — Disease due to the larvae of the *Taenia Echinococcus*, a flat worm habitually a parasite of the dog and especially affecting persons in contact with this animal (those engaged in cultivation, shepherds, butchers, pork butchers). Man becomes infested by ingestion of the eggs: food soiled by infected excreta of the dog, intimate contact with dogs having their mouths or tongues contaminated by eggs. Cases have been reported as affecting women in Iceland engaged in milking ewes contaminated with the excreta of sheep dogs (M. Einarsson). The eggs swallowed lib-
erate hexacanth embryos in the stomach which become distributed throughout the system by the circulation and form the centre of cysts giving rise to various symptoms dependent on their localisation (liver, kidneys, abdominal cavity, lungs, etc.).

FORMS OF ITCH. — Forms of itch are cutaneous lesions caused by acari which live either on animals or on vegetables. There are also designated by this name the various types of dermatitis due to acari.

In addition to human itch due to the *Sarcopes scabiei* or itch mites, which may affect those persons coming in contact with dirty individuals or soiled clothing (nurses, rag sorters, etc.), there exists a whole series of animal itchies due to the habitual parasites of a large number of irritants. These forms of itch are almost always without furrows, assuming the aspect of millinary or polymorphous eruptions of a diffuse and pruriginous type, yielding easily to treatment, and healing.

Brumpt reports cases of transmission to man by the following animals: horse, donkey, mule (keepers, coaches, stable boys, veterinary surgeons, etc.); goat, sheep, pig (agricultural workers, shepherds); cat, dog, rabbit, ferret fox, (for instance, one case affecting a hunter who had skinned a contaminated fox), llama, camel (keepers: Cross); staff in menageries, amongst whom camel itch takes a fairly serious form (Brumpt).

*Trombidiosis* should be mentioned here (due to *Microtrombidium pusillum*, a type of harvest bug, the larvae of which infest chickens and various small wild animals (mole, hedgehog) and may attack man). They climb up the legs and accumulate at the level of any clothing which bars their progress (garters, suspenders, belts) causing pruriginous papules which at times set up fever and insomnia and may give rise to extensive erythema (autumn erythema). Agricultural workers and poultry breeders, gamekeepers and haymakers are often affected (Guerrini) and the condition is very prevalent in the Southern States of America.

*Ticks* (*Ixodes Ricinus*), the adult female of which lives on the skin of animals (dogs, cattle, sheep, horses, etc.), affixing itself by its rostrum, causes in man at the point of fixation a red oreole with a fair amount of itching and a small tumour when there is penetration under the skin (Blanchard, Mégnin). There are no further symptoms unless the animal, being removed roughly, leaves its rostrum in the skin, or unless there is inoculation by septic germs (*bacillus anthracis*: Calandruccio). Salamanque has described (1892) under the name of "ixodiasis" symptoms noted among Spanish peasants during haymaking, characterised by vomiting, urticaria, and diverse disturbances of a local and general order.

Other acari again alive on birds: pigeons (*Argas reflexus*), chickens (*Dermanusius avium* or *B. Gallinae*), and may affect persons engaged in rearing these animals. According to Guerrini, poultry breeders' itch is a form of dermatitis which is at first erythematous, then papular, eczematous, pustular, and highly pruriginous with lesions due to scratching caused by the bite of the parasite, the saliva of which is hemolytic and irritant.

A whole series of sarcopitidae live on grain and fruit or on the insect parasites inhabiting grain and fruit and may cause in man eruptions which are likewise pruriginous but disappear rapidly after some days. General manifestations are rare when these exist are due to toxines (Bernstein).

The chief form of dermatitis of this kind noted during manipulation of wheat is due to *Pediculoides Ventricosus acarus*, which is a parasite of the larvae and nymph of a type of lepidoptera (wheat linea or moth). It causes in man a polymorphous, papular or papular-vesicular erythema accompanied by very violent itching and sometimes fever (temperature 39-40° C.; grain fever: Guerrini). This disease occurs amongst agricultural workers, sorters and cleaners of grain, millers or carriers engaged in transport of grain, carters, railway workers, but chiefly amongst dockers, amongst whom veritable epidemics have been reported on several occasions in different countries (see article "Dock Labourers").

Analogous forms of dermatitis have been noted during manipulation of cotton (London dockers engaged in transport of cotton seeds (O'Conner, 1913), dried peas (Macri, 1915; Nixon, 1916), straw, cereals (Sachs, Schamburg, Sberna), barley (Hodara, Behrdjet, Sureva), and amongst warehouse workers (Blaschko, etc.).

Other forms of dermatitis are due to the *sarcopitidae* (*Tyroglyphus longior*) found on coconuts. Castellani has described "copra itch" amongst workers handling coconuts in the country of origin, and also amongst workers unloading these in ports.

The same author has described "pineapple estate pyosis" amongst planters of pineapples in Central America,
characterised by pustulae and ulcerations located on the arms and legs and which he attributes to the action of arcari, though he was not able to prove this.

Other analogous forms of dermatitis have been noted amongst workers in tea plantations in India (for example, *Rhizoglyphus Paraticus*, a cutaneous eruption commencing between the toes and spreading to the ankle-bone: Dalgetty), amongst workers handling vanilla pods containing moths or moulds (*Tyroglyphus Siro*). (See articles "Perfumes" and "Skin Diseases").

There has likewise been reported a form of itch affecting grocers (Murray) due to *Glycyphagus domesticus*, characterised by a violent eruption of the skin which is, however, transient, similar to itch due to *Tyroglyphus point豇豆* caused by wheat from certain districts (Moniez).

The title of this article is extended to cover bites and forms of dermatitis due to certain insects, among which may be mentioned mosquitoes (Oxitec pipiens, *culex anulatus*, etc.), anopheles mosquitoes, which bite workers in forests and fields and set up forms of urticaria and eczema at times complicated by lesions due to scratching.

Brumpt has noted amongst market workers engaged in the sale and transport of large game bites due to lipoptene (*Lipoptene cervi*), which live in the month of September on large game (deer, roe deer, wild boar) and set up analogous lesions (leaving no immediate visible lesion), a hard pruriginous papula which sometimes persists for fifteen days. Brumpt refers also to analogous lesions (invisible bite with appearance on the following day of a slightly pruriginous papula) due to an insect *Melophagus ovinus*, which lives in the fleece of sheep and often bites workers during shearing.

**MYIASIS. —** Under this name are designated certain skin affections due to insect larvae (*Diptera brachycera*). The larvae which are essentially parasitic cause cutaneous myiasis (sub-cutaneous spreading myiasis, sub-cutaneous myiasis with creeping tumours, myiasis accompanied by carbuncles): the larvae which, on the other hand, are free living, i.e. not essentially parasitic, set up myiasis in the body cavities and intestinal myiasis.

Creeping myiasis starts with an extremely painful sub-cutaneous spot and spreads in a cutaneous manner, its progress being traced by a red ecchymotic line, which is effaced in several days. When the larva accomplishes its exit, the pain remains stationary and a small tumour develops at the spot, the apex of which becomes perforated, permitting the exit of the larva and at the same time of a seropurulent liquid. Amongst the larvae may be mentioned those of *Cochliomyia macellaria*, which at times gives rise to serious symptoms among breeders of domestic animals (Brumpt): of *Phormia regina*; and of *Gastrophilus intestinalis*, a case of spreading sub-cutaneous myiasis being recorded as having been caused by the latter and affecting a groom at Saskatchewan, Canada (case recorded by S. and L. Corrigan in 1925).

Sub-cutaneous myiasis, accompanied by spreading tumours characterised by a type of carbuncle occurring at the moment of exit of the larva, is well known amongst peasants in Norway (Hoegh), Ireland and Scotland (Whitaker, McCalman) and in Brittany, etc.

Myiasis of the cavities is due to the development of larvae of the dyptera in the natural cavities of the body (nasal fossae, orbit of the eye, external auditory meatus, genital and urinary passages and wounds, etc.). There have been recorded cases of ocular myiasis amongst shepherds (Galvagni, 1845), cases of myiasis of all the natural cavities of the body amongst arab shepherds in Algeria due to *Oestrus ovis*, and cases of vulvitis and vaginitis caused by myiasis amongst field workers (Jarisch).

An affection which resembles forms of myiasis is "cheese workers’ itch" (Guerrini), affecting persons engaged in the cheese industry, especially those who handle milk; shop assistants and those engaged in the transport of cheese are also affected. It is due to *Piophila casei*, a cheese maggot which lays its eggs in cheeses and on the residual products of fermentation. The larvae having once developed, may settle in the inter-digital spaces, on the back of the hand and forearm, setting up punctiform and linear lesions with a pigmented base, raised and hyperaemic edges accompanied by pruritis and aggravated by lesions due to scratching (Guerrini).

**ONCHOERCOSIS (VOLVULOSIS).** African onchoercosis is a cutaneous disease due to a thread worm *Onchocerca Volvulus*. According to Brumpt, in the Belgian Congo 5 per cent. of the peasants are affected by this disease, which is characterised by a papulopustulous and very pruriginous eruption or by lichenification of the skin and elephantiasis.
American onchocercosis is due to *Oncocerca Caecutiens* and consists in cutaneous lesions accompanied by general symptoms (erysipelas of the Guatemalan coast), encountered chiefly amongst workers on the plantations (Joyeux).

**Oxyuros.** — A disease due to a round worm (*Nemathelminia*, *Oxyurus Vermicularis*), a parasite peculiar to man and inhabiting the large intestine.

Infection occurs by accidental ingestion of the eggs. Social conditions are only an influence in so far as they multiply opportunities of contact between infected individuals and healthy individuals or between the latter and the excreta of the former (soldiers, miners, cesspool workers, etc.: Brumpt). Guerrini has recorded cases of this disease characterised by anal vesperal pruritis amongst laundry-women engaged in washing clothes by old methods, infection occurred by accidental ingestion of faecal matter from the soiled clothing. Those most liable to infection are the workers who collect and sort the linen rather than those actually engaged in washing and drying.

**Paragonimosis.** — This disease, well known as "pulmonary distomiasis" or "parasitic haemoptysis", is due to a flat worm, the *Paragonimus Westermani*, a habitual parasite of domestic animals.

It is characterised in its most usual pulmonary form by coughing, blood-stained sputa and at times general benign haemoptysis, which may, however, endanger life.

The cerebral form, which is a complication of the above, is characterised by headache, vertigo and epileptiform attacks.

According to Guerrini, the disease in question is chiefly an affection occurring in mountainous regions and affecting particularly quarrymen, stoneworkers and workers in marble quarries.

**Pediculosis.** — In its three forms — pediculosis of the head (Pediculus capitis), pediculosis of the body (Pediculus vestimenti) and pediculosis of the pubis (Phthiriusinguinalis) — this disease is met with amongst individuals (nurses, rag merchants, etc.) coming in contact with contaminated persons or material.

**Sarcopsylliasis.** — Disease due to the *Sarcoptes ou pulex penetrans* or jigger, an exotic insect (tropical America, Africa). The female, after fertilisation, penetrates under the skin of warm-blooded animals or man (feet and legs). Native porters are very often affected (Brumpt).

**Trycocephalosis.** — A parasitic disease due to a nematoid worm, the *Trycocephalus hominis* or *Trichurus Trichiura*, a parasite known as the whipworm, peculiar to man, the infection being caused by swallowing eggs in the embryonic state. These live in water and in the ground, and are resistant to heat, cold and putrefaction. Eggs may be ingested with drink or food in the raw state or may be carried to the mouth by dirty hands (miners, farm workers).

The symptoms consist in nervous and digestive troubles and at times pernicious anaemia.

**Legislation**

See article "Occupational Diseases: Definition and Compensation".

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**Pearls (Artificial)**

**French:** *Perles artificielles (fabrication des)*. — German: *Fabrikation unechter Perlen*. — Italian: *Fabbicazione di perte artificiali*. — Spanish: *Perlas artificiales (fabricacion de)*.

**Technical Data**

The first artificial pearls made were hollow. Though at the present time solid pearls are the fashion, hollow
Pearls (Artificial)

Pearls are still manufactured in large quantities and for a number of special purposes: for trimming dresses, for large earrings, etc. Hollow pearls are essentially transparent beads made of blown glass, the interior wall of which is coated with a nacreous lustre. This lustre is obtained by injecting into the glass bead a mixture formed of gelatine and a product known as essence d’Orient. Except in the case of very high class pearls, this mixture is introduced mechanically into the bead. After filling, the pearl is emptied, leaving only a thin layer giving the nacreous shading. For this purpose the pearl is slightly heated and then allowed to dry. Finally, in order to give it weight, it is once again filled with white wax which is injected by blowing by the mouth or mechanically, a vacuum being created under the tables of a pneumatic machine. The pearl is again dried, then washed to remove external soiling.

Pearls made in this way conserve their appearance perfectly as long as they are not washed in hot water or brought into contact with alcohol solutions.

Contact with the skin has no effect on these pearls since they are coloured internally. The colouring process is practically the same for all colours and consists in the addition of colouring matters to the solution used for imparting the nacreous lustre. The hollow pearls are sometimes rendered iridescent. In this case it is the outside of the bead which is iridesced by applying salts of titanium in a hot state. The manufacture of these pearls does not, in short, involve the use of any toxic product. Complaints have been made in regard to the operation of blowing glass beads by the mouth. This operation, effected by women, consists of blowing into the inside of the bead the mixture of essence d’Orient and gelatine. Continual repetition makes it a tiring process, but there is no further inconvenience. It has been alleged, without proof, that tuberculosis was of frequent occurrence amongst these women workers. In fact, only the manufacture of the small hollow glass beads is trying and may cause chronic poisoning by reason of the combustion gases liberated in the overheated and badly ventilated workshops in which the women are engaged.

For the last ten years the manufacture of “solid pearls” has been carried on on a very large scale. It is totally different from the preceding process; the principal operations are as follows:

The small solid bead is made of a milky enamel which is caused to adhere in a molten state to a hollow copper wire by means of a blowpipe. Women and young girls do this work by hand. Beads are then detached by plunging the wire, which serves as their support, into nitric acid, which dissolves the copper. The beads thus prepared are stuck on to iron or wooden supports fixed on a wooden board covered with plastic material. The operation of imparting a nacreous lustre then follows. The solution employed for this purpose consists of an alcohol-ether collodion which is mixed with essence d’Orient. A series of processes consisting of dipping and drying then follows, terminating with dipping in an anyl acetate collodion.

About five years ago certain manufacturers, instead of following the above process, commenced to use a collodion consisting of tetrachlorethane. This collodion possessed the advantage of not being inflammable and of providing a more solid coating substance. Its use has, however, been given up for reasons which will be mentioned later, and consequently there are no more serious cases of tetrachlorethane poisoning to deplore. Pearl manufacturers no longer use this product unless for the manufacture or iridescent pearls, and therefore in very small quantities.

An iridescent aspect may also be obtained by the use of bismuth oxychloride.

For setting, a white lead paste is often used.

Pathology

The workers engaged in the artificial pearl industry are subjected to various kinds of poisoning more or less serious in character. The manufacture of beads involves exposure to slow poisoning due to liberation of volatile products in the incomplete combustion of the gas, carbon monoxide being present. The melting of the copper wire in nitric acid gives rise to intense liberation of nitrous fumes, which constitute grave danger for the respiratory passages.

Amongst the products employed in imparting a nacreous lustre to the
pears is amyl acetate, which though not very poisonous may cause transitory symptoms: vertigo, headache. At the end of eight or ten days, the majority of women workers no longer feel the effects of this solvent, which has a characteristic smell noticeable at some distance.

On the other hand, tetrachlorethane has been the cause of serious cases, some of them fatal. In France, Frois has reported three cases of this type. The victims, three women, were employed in dipping the pearls. All three died of toxic jaundice due certainly to tetrachlorethane fumes. Frois made an investigation in the factories in which these women workers were engaged, and in a paper read to the Academy of Medicine on 11 July 1922, called the attention of the medical authorities to the dangers attending the use of tetrachlorethane in pearl factories.

Clinical observations made in this connection date from the same time. In 1922, Leri and Breitel described two interesting cases met with amongst pearl makers who suffered from polyneuritis with anaesthesia and paralysis of the fingers and toes, accompanied by interosseous atrophy. They also found symptoms affecting the central nervous system, with loss of deep tendon reflexes, ataxia in walking, cramp, heaviness of the limbs, but no pain. The tendinous reflexes may be entirely abolished; the pharyngeal reflex and the soft palate are affected at an early stage. Recovery was very slow. The two workers in question had been engaged in dipping the pearls and exposed to toxic fumes during ten hours per day. Before using the coating material they filtered it under pressure through a cloth, and so had their hands covered with it. These authors admit of two paths of absorption of the toxic product — by way of the respiratory passages and by way of the skin — with a possible third entry by way of the digestive tract.

At the sitting held on 15 January 1923 of the Forensic Medicine Association of Paris, Leri cited the case of a woman worker employed in the manufacture of artificial pearls who showed the following main symptoms: jaundice and, as regards the nervous system, also symptoms resembling drunkenness, ataxia in walking with paralytic phenomena affecting the extensors and interosseous muscles. There was loss of the tendinous reflexes, of the pharyngeal reflex with anaesthesia at the level of the toes and retarded response to electric stimuli. Similar symptoms appeared in the case of a woman worker who had preceded the patient on the same work.

Fiesinger, Brodin and Wolf have related two cases, one a young girl employed in drying pearls who at the end of three weeks' exposure to tetrachlorethane fumes suffered, after a short phase of digestive trouble, from benign jaundice with transitory amenorrhoea. The second case, one of those referred to by Frois, had fatal consequences: a woman aged forty-six lost, followed by alcoholic excess, who suffered at first from benign jaundice complicated later by other symptoms. After a rest she returned to the factory, but developed severe jaundice which ended fatally.

The two other fatal cases of jaundice quoted by Frois occurred in a different factory. They have been described by Charbonnier in his thesis. The victims were two young girls engaged in dipping pearls in a badly ventilated factory. They suffered from digestive troubles, anorexia and vomiting, followed by jaundice of a toxic character which was not immediately diagnosed.

A Russian study dated 1930 deals with working conditions in a factory making artificial pearls and the paste for them. The chief source of injury resided in the use of amyl acetate and ether (solution of nitrocellulose in allyl alcohol). The women workers inspected complained of nervous troubles, headaches and fatigue. The liver was distended and painful under palpation. Examination of the blood revealed irritation of the haematopoietic organs (S. Frumkina).

**HYGIENE**

The workshops in which beads are made by blowpipe should be spacious with high roofs and well ventilated from the upper part. It is difficult to install ventilators with a big drop in pressure, for the work cannot be carried on effectively in a draught, since the flame from the blowpipe must remain upright in order to melt the enamel in a satisfactory manner.

Dipping in nitric acid should be effected under an exhaust hood provided with a chimney which draws well. This process was, a matter of fact, given up some time ago. Instead of making the bead by hand on a hollow copper wire, the enamel is now attached by the blowpipe to a solid copper wire stretched between two supports. To remove the beads it is only necessary to withdraw the wire.
Hygienic conditions are much more satisfactory where this method, which is patented, has been adopted.

Imparting a nacreous lustre to the pearls may perfectly well be effected with alcohol-ether and amyl-acetate collodions, and the use of tetrachlorethane colloid should be forbidden, at least for this purpose. In France the majority of manufacturers have already been requested to abolish its use. They have, moreover, admitted that pearls made in this way are apt to have a rather indefinite smell, recalling that of chloroform. With the elimination of tetrachlorethane colloid in coating the pearls the serious toxic accidents referred to above have disappeared.

For the making of iridescent pearls tetrachlorethane is frequently used, but only in exceedingly small quantities.

All the above operations, whether dipping, coating or rendering iridescent, should be effected inside glass cages, provided with holes through which the arms of the workers are passed, and at the bottom of these cages there should be installed a pipe communicating with an exhaust duct, creating a slight drop in pressure and removing the toxic fumes.

As a general rule, workrooms where these operations are effected should be spacious, well aired and well lighted.

Special precautions require to be taken for the safety of the staff since the products manipulated are particularly inflammable.

Though the use of tetrachlorethane is at present limited, periodical medical supervision is advisable, as early diagnosis would permit of the withdrawal of women workers in danger of developing poisoning.

Also, it is advisable to exclude from this work women suffering from any kidney or liver trouble. It should be noted particularly that relapses are extremely serious, if not fatal, in the case of the poisoning in question.

On account of possible absorption of the toxic product by way of the skin or digestive passages, strict personal cleanliness should be demanded on the part of the women workers. Cloakrooms and adequate washing accommodation should be available. After several months a rest of two or three weeks and change of work is advisable for women engaged in the manipulation of the toxic products in question.

For compensation in the case of injuries due to tetrachlorethane, see that article.

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**Perfume and Essence Industry**


Under the name of perfumes are designated a large number of natural or artificial products of complex composition characterised by their smell. The majority of natural perfumes come from plants in which they are found in a state of essential volatile oils. According to the plant in question these essential volatile oils are contained in different parts: root, underground stalk, wood, bark, leaf, flower, fruit or seed. Some plants furnish besides several characteristic perfumes varying with the part from which they have been extracted: anise, bergamot, lemon, iris, lavender, jasmine, neroli or orange flower oil, origanum, geranium, etc.

The essential oils are generally present in the form of volatile odoriferous liquids capable of distillation without being subjected to decomposition and are composed of different constituents, in one or several of which is concentrated the characteristic aroma of the essential oil. These oils are generally soluble in absolute alcohol, ether, carbon bisulphide, petrol and numerous other organic solvents.

The properties and composition of the various essential oils differ greatly. The isolated compounds of these oils are generally hydro-carbides of the terpene series, alcohol ethers, especially ketones of the terpene series, or alcohols of the geraniol or citronellol type, phenols and their derivatives (etherophenols), substances of the alkaliphatic series, acid and ether compounds, lactones and oxides, nitrated or sulphurated compounds.
Perfumes of animal origin are the product of secretions or excretions. Amongst the principal of these may be mentioned musk, civet, ambergris, castoreum.

Artificial perfumes do not generally possess such a fine odour as these natural products, but have the advantage of being usually much cheaper. Certain perfumes are the synthetic reproduction of the odoriferous principles of natural perfumes. Others are new odoriferous products having the same odours as the preceding ones but not their chemical constitution; others again are entirely new perfumes. Certain substances, moreover, though having a similar odour to that of natural products, are not found in nature.

It was a synthetic production of vanillin by Tiemann and Haarmann which marked the rise of the artificial perfume industry, which is now steadily developing. Amongst the substances which are used for artificial reproduction of some elements constituting the characteristic perfumes of natural products may be mentioned acetate of lynal (bergamot essence), benzoic aldehyde (essence of bitter almonds), methyl salicylate (essence of gaultheria), coumarin (tonka beans), as well as a number of other products: terpineol (essence of cardamom, marjoram), borneol (aspic, lavender, rosemary, marjoram), etc.

It is absolutely impossible to cite all the substances possessing an odour similar to these natural products or perfumes. It must suffice here to recall the following: beta-naphthol ether (acccia), nitro-benzene (bitter almonds), acetophenone (various aromatic odours), anisic aldehyde (new mown hay, hawthorn, or May blossom), benzilidine acetone (coumarin, sweet pea), salicylic aldehyde (“queen of the meadow” essence), amyl acetate, ethyl acetate, iso-benzylidene acetone (“enfleurage” concrete from which the essential oil is separated by extraction with alcohol).

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Industrial Operations

A. — Preparation of Essential Oils

This is done by means of different processes varying in accordance with the kind of essential oil to be obtained.

(1) Extraction by hydraulic press (for substances rich in volatile oils: orange juice, lemon juice, etc.). — The oils obtained are separated from the aqueous liquids by means of decantation and filtration.

(2) Distillation (in the case of certain flowers containing odoriferous substances in almost complete form). The products are generally distilled in a fresh condition but sometimes after drying or conservation in salt water. Where the products in question consist of seeds, wood or roots, they are shredded or grated prior to distillation; others are submitted to fermentation by simple maceration in water in order that the fermenters and enzymes may liberate essential oils fixed in the plant in the form of glucosides or other combinations.

Distillation may be effected by water or by steam (sub-pressure, reduced pressure, vacuum). The essences and perfumed waters are obtained directly and collected in suitable recipients.

(3) Extraction by use of a volatile solvent (for delicate flowers poor in essence, or for certain other products: sandalwood, cedarwood, rhizomes of the iris plant, vanilla, etc.). — Alcohol, petrol ether, ether, chloroform, carbon bisulphide and benzine are the chief solvents used. A compact mass formed of essential oils mixed with wax, fatty and resinous substances is formed, these substances being the “concretes” from which the essential oil is separated by extraction with alcohol.

(4) By means of non-volatile solvents (“enfleurage” by a cold process or by absorption”). — On each side of a glass placed in a wooden frame or “chassis” a layer of fat is spread (beef, pork or mutton) which has been purified, and on to this the flowers are spread and left for a period varying in each particular case. The frames are piled one on top of the other and the plant continues in flower, which usually involves a period of two to three months, this process being continued until the fat is completely saturated with perfume. In enfleurage by the hot process, or by maceration, the flowers are thrown into the melted fat, which is steam-heated in a double recipient, and when the flowers are used up they are removed and replaced by others until the point of saturation of the fat is reached.

At times solid fatty substances are replaced by olive oil, or better still by vaseline or paraffin, which possess the advantage of not turning rancid. In the first case, material spread on frames is impregnated with olive oil and the process is effected as described
above in enfleurage by the cold process. The material used is then subjected to pressure for extraction of the perfumed oil. In extraction with vaseline the flowers are placed between the plates of a filter press heated to 50° C., which removes the molten vaseline.

The fatty substances charged with perfume constitute a kind of wax which, subjected to suitable treatment, provides essential oils. The latter are thereafter freed from their insoluble impurities (water, pectic and mucilaginous substances) by allowing them to stand for a certain time, by decantation and filtration; and from soluble impurities (varieties of waxes, fats, resins, colouring matters), by means of distillation and rectification.

The essences are mostly subjected to a process of determinisation with a view to ridding them of inodorous or slightly odorous compounds (terpenes and sesquiterpenes), thus increasing the strength of the perfume and rendering them more soluble in dilute alcohol, and at the same time assuring better conservation.

The final products obtained constitute concentrated soluble essential oils (deterpine essences, quintessences and absolute essences). Their solutions in alcohol constitute the flower “extracts”, which after removal of the alcohol by distillation in vacuo give the “absolute flower oils”.

B. — Manufacture of Artificial Perfumes

This is highly important, since the majority of natural perfumes have been reproduced by synthetic processes, but many are still extracted from low-priced natural essential oils, either by fractional distillation or by other mechanical operations. The most important are perhaps ionone (violet odour) and vanillin (odour of vanilla).

Recent developments in the technique of the manufacture of artificial perfumes consist in the discovery of juperitone and synthetic thymol, and especially in the perfectionment demanded by fashion which singles out a particular perfume. There should be mentioned also the synthetic preparation of borneol, connected with that of camphor and terpinol. The synthetic preparation of thymol by simple hydrogenation gives menthol, and that of menthol — which can also be produced by reduction of piperitone — gives vanillin or hydroxycitronellol.

C. — Preparation of Various Perfumery Products

Essential oils and artificial perfumes are employed in the manufacture of a large number of well-known toilet preparations in liquid, solid, paste or powdered form. Certain essential oils or certain synthetic perfumes are used in the manufacture of artificial aroma for wines, liqueurs, confectionery, and in the food, pharmaceutical, paint and varnish, etc., industries. Besides extricents which receive the perfume there are often added fixing agents designed to retain the transient odours as long as possible. These are either substances with their own very durable perfume; or inodorous substances capable in a high degree of holding the very volatile essential oils, or again they may be absolute essences (of flowers), resinous substances, oleo resins, or finally compound fixing agents. The fixing agents chiefly employed are amber, musk, civet, ambrette, benzoin, storax, Peru balsam, balm of tolou, incense, myrrh, etc. Amongst the artificial products may be mentioned the ethers of formic acid and of benzyl (acetate, benzoate, salicylate).

Natural colouring agents are used for colouring perfumery products (saffron, false saffron, caramel, cocheinal, campeachy wood, sorrel, etc.), and more commonly artificial colouring agents.

After preparation the perfumes are kept until the various products they contain have become thoroughly homogeneous.

TOXIC ACTION

Injuries met with amongst workers in factories for the manufacture of perfumes or perfumery products have been related either to the harmful action of the products manufactured or handled, or to the action of the odours involved.

The disinfectant and narcotic effect of ethereal oils is known (Geinitz, 1912); likewise, that of thuyone of myristicine, of nutmeg, of wallflower (Jürso), of safrone and isosafrole (oil of saxifrage) (Heffter and Waldvogel), of coumarin, of essence of odoriferous asparagus, and of clover (Rober). In guinea pigs the fumes of essence of anise (Albein, Meunier and Cadéac) immediately cause excitement, violent irritation of the nasal and mucous membrane, spasmodic movement and fibrillary trembling recurring every five to six seconds. The animals thereafter show signs of inebriety and somnolence, which lasts for a long time.
With slight doses the effects are less intense and more transient. Similar symptoms have been noted in experiments on frogs. In 1879 Masoin and Bruyland caused convulsions, somnolence and trembling in pigeons and rabbits. The most toxic of the essences utilised was that of rosemary, followed by thyme and lavender; essence of marjoram was almost without effect. These essences have been considered as likely to give rise to convulsions on account of their terpene content.

Here (1893) brought about retarded development, miscarriage, and production of monsters by submitting eggs to the action of anise, wallflower and lavender.

In a general manner it may be said that the injuries due to essential oils are analogous to those caused by ethers, hydrocarbides and aldehydes. Still more serious lesions have been noted (nephritis), and even tumours (see article “Occupational Diseases: Urogenital System”). Apart from a general toxic action in the strict sense essential oils may affect the mucous membranes (eyes, nose) or the skin, causing localised irritation related partly to the phenomena of ana-phyllaxis, and interpreted most commonly as resulting from individual constitution. Other sources of danger are represented by solvents used for the extraction of the perfumes. Hayhurst has reported a case of acute poisoning due to ether.

As regards odours (see that article), it must be stated, on the one hand, that the majority of workers usually become accustomed to the odours connected with their occupation, and, on the other hand, that concentrated essential oils have in any case very little odour. At high concentration has such a feeble smell that the first person who succeeded in manufacturing it did not recognise its value as an odoriferous product. It is in fact only by means of dilution that these products acquire value as perfumes.

STATISTICS

Statistical data are very scarce. Reference may be made to a health enquiry made by the New York Bureau of Women in Industry (1928) which, for a period of three months, collected medical statistics concerning three factories employing a total number of 1,757 workers. The majority of the operations were dusty, and consequently the chief disorders found were irritation and diseases of the upper respiratory passages. In one factory employing 660 women, there were 526 cases of disease, of which 26.2 per cent. were respiratory; in the second employing 388 women, 554 cases of disease, of which 46 per cent. were respiratory; and in the third employing 708 women, 2,411 cases of disease, of which 34.4 per cent. affected the respiratory system.

This enquiry revealed the importance of hygienic working conditions. In fact, the factory which had the most defective conditions from this point of view had an average of 3.45 cases of sickness per employee, whilst in another — in which greater attention was bestowed on hygiene — the average fell to a little below one case per employee.

PATHOLOGY

The manufacture of odoriferous oils and essences is likely to give rise to similar accidents to those met with amongst workers exposed to alcohol ether fumes. The more marked convulsive phenomena noted are to be explained by the greater toxicity of the fume.

Certain authors have asserted that inhalation of perfumes handled (workers in the perfumery industry, bottling, retailing of volatile essences) may give rise to all the evil effects of aroma poisoning. According to Imbert-Guerbeyre, Lanceraux and others, staying in an over-perfumed atmosphere tends to cause acute and chronic symptoms characterised by headache, vertigo and neuralgia (of the head), especially amongst new workers. Perfumes or essences of hyacinth, heliotrope, jasmine, tuberose, musk and patchouli are said to cause violent headache rather easily (Layet). They are colloquially called “heady” perfumes. Other symptoms noted are a state of general discomfort accompanied by sweating, nausea, cardiac oppression, vomiting, muscular and articular pains, nervous and digestive troubles, and general weakness. According to Layet, certain perfumes are said to be more likely than others to cause discomfort amongst those obliged to manipulate them, and he noted in particular the perfumes or essence of almonds, which enters into many perfume preparations; the perfumes or oils of citron (Citrus medica genuina), bitter oranges, bergamot and lemon give rise to nervous disturbances and are fairly characteristic amongst the workers who grate the rind of the fruit.

Injuries vary according to the process of preparation followed. Layet noted that in his time workers engaged on distillation were more frequently attacked, and that nervous disorders of a complex nature were very frequent amongst workers engaged on extraction of perfumes by means of ether
and carbon bisulphide. Diseases of the respiratory system were likewise of not infrequent occurrence.

Lehmann, however, states, on the evidence of a large German factory for the production of essences and perfumes, that at the present time there may hardly be said to be any specific diseases affecting workers engaged in the manufacture and mixing of ethereal oils. In drawing attention to the fact that medical literature contains accounts of numerous cases of persons who had developed illnesses as the result of having inhaled the perfumes of large quantities of oranges and of flowers, Lehmann considers that the individuals in question must have been particularly sensitive, and that it would be hard to determine whether the diseases noted were entirely caused by the perfumes inhaled. It is, however, certain that perfume workers are hardly ever, if at all, inconvenienced by their work, for according to certain authorities the sensorial terminations of the olfactory organ are quickly dulled by odorous substances when the latter are present in an unduly large quantity. Whilst, however, tolerance seems to be the rule, there are nevertheless certain susceptible individuals and particular idiosyncrasies, notably as regards certain substances (for instance, phenyl-acetaldehyde and indol).

Amongst local injuries there have been noted cases of acute rhinitis and epistaxis, as a reaction to stimulation of the mucous membrane amongst hunters of musk-deer. There have likewise been noted various olfactory developments at times; there occurs a persistent sensation of the odour noticed during work (chiefly at meal times): at times there is attenuation and tolerance with marked exhaustion of the olfactory sense.

Forms of conjunctivitis are frequent, as well as styes, and sometimes even lesions due to foreign matter (dust, etc.). Dermatitis and lesions of the nails, especially discoloration of the nails, are also common.

In the American enquiry referred to above, lesions of the latter type were of higher incidence than amongst workers engaged in a candy factory and much higher than the general figure for occupational dermatitis. The lesions generally consist of boils on the hands, and more especially on the face and neck.

A woman worker engaged in dipping toothpicks in cassia oil (a type of acacia plant), to give them an agreeable odour, suffered from dermatitis of the hands with vesicular eruptions, redness and spots on the face and abdomen. This oil was a cheap substitute for cinnamon oil (Prosser White). Eruptions with erythema, papules and vesicles situated chiefly on the hands are caused by essential oils of orange (Kober and Hanson). Serious and obstinate cases of dermatitis have been noted amongst perfume makers and workers engaged in the preparation of hair lotions (Sachs). Particular symptoms are also reported as occurring in consequence of manipulation of distillates of copaiba balm. The urine had a violet odour similar to that caused by turpentine essence.

Similar accidents have arisen from manipulation of vanilla. As far back as 1883, Layet referred to lesions frequently encountered at Bordeaux, at which port 23,000 kg. of vanilla are unloaded per annum. The work in the warehouse was distributed as follows: sorting with a view to separating vanilla in good condition from vanilla containing moths or moulds, brushing to remove the moths and moulds from the pods, repacking or boxing the pods.

Verdalle found a case of vanillism affecting a worker engaged in a liqueur factory in cutting the pods into small pieces. Other cases of vanillism have been studied by Hutchinson (London) and Schultz (Wurzburg) in 1892; by J. C. White in 1893 and by Guérin (Paris) in 1895, who noted erosions and superficial excoriation of the eyelid due to the oil contained in the pods, conjunctivitis at times simple and at times accompanied by ulceration, painful tension and heaviness of the eyes, progressive weakness of sight which in certain cases amounted to amaurosis; by Gieseler (Bonn thesis, 1896), Harning (Berlin, 1897), Audéoud (Geneva, 1899), Brock and Fage (1906), Haley (1906), etc. The causes of this disease have been the subject of much discussion. According to certain authors, the injuries are said to be due to a parasite closely related to the acarus (Valin, 1897). Others attribute the affection to the action of moulds, and others, again, to a substance used in preparing or reproducing vanilla. It must however be taken into account that even vanillas which have not undergone manipulation — in fact, the whole vanilla plant — are toxic (Claverie). It is for this reason that it has been thought that the harmful principle is contained in the oily juice which escapes from the pods, and that its action is aggravated by other factors (particular susceptibility, other irritant substances present, etc.).
In 1803 P. White noted cases of acute dermatitis which he attributed to the action of cardol (oil) rather than to that of an acarus from the pod.

According to observations of Brock and Page and others in cases of blepharitis and conjunctivitis amongst persons coming into contact with vanilla dust, the injury has again been attributed to an acarus or mould. Other authorities, again, have attributed the trouble to catechu colouring matter used for colouring the sticks of vanilla.

The sticks of vanilla are often placed in recipients containing alcohol. Splashes of this liquid may induce redness and dermatitis of the forehead, face, etc., amongst sensitive workers.

While studying a case of vanillinism, Lortat-Jacob and Solente (1929) were able to determine that the cause of the injuries was proteins present in the pod rather than the vanilla. The benzoic acid crystals found in the shape of a crystalline efflorescence consisted of a vanillin known as "givre", on the surface of the vanilla have also been blamed, since they constitute an irritant and cause a burning sensation.

Vanillinism is a disease at once general and local.

The general phenomena are represented by headache, vertigo, somnolence, singing in the ears, forms of neuralgia, cramp, insomnia, muscular pains and vesicular irritation. In the more or less serious cases studied by Audouëd cutaneous and nervous troubles were complicated by affections of the genital organs: genitic stimulation, lassitude, muscular pains, etc.)

Nervous symptoms (headache, giddiness, lassitude, muscular pains, vesicular irritation, etc.) have been attributed to the odoriferous emanations, and are met with especially amongst workers and chemists engaged in the manufacture of vanillin.

Cutaneous manifestations consist of papulo-erythematous eruptions on the hands, neck and face of a highly pruriginous type accompanied by oedema resulting very closely a form of erysipelas. The eyelids also are affected with oedema. Brock described a case of transitory alopecia of the eyebrows very shortly after the outbreak of the eruption. Furfuraceous desquamation of an intense type was present. The hair of the head remained unaffected.

In the slight form there has been noted papulo-erythematous and pruriginous eruption confined to the hands and certain parts of the body, together with headaches.

The recurring phenomena are chiefly the following: generalised eruption as soon as the worker enters the factory. Such workers are soon driven from the work. When this form of the disease is confined to small outbreaks of papulæ the patients may resume the occupation, though from time to time they suffer from more marked attacks. In a third series of cases the cutaneous symptoms are not very intense, and in a fourth absolute tolerance sets in. The cutaneous troubles are more or less marked during several years and finally they become quite mild.

There should finally be mentioned certain cutaneous symptoms described by Loriga, Sutherland-Campbell, Shapiro, Horner, etc., amongst workers engaged in peeling and squeezing lemons and oranges for the juice. According to Sutherland-Campbell, the complaint in question is a paronychia caused by a mould peculiar to the oranges which rapidly attacks the pulp of the fruit. In the case of the worker affected, the skin of the fingers in contact with the juice or the pulp is rapidly infected, and there is erosion of the nails with collection of pus underneath.

Loriga (1927) has studied cases of dermatitis caused by juice and essence of lemon. In general it is the left hand that is affected, more rarely the right. The skin assumes a whitish, pale colour, and dermatitis of a painful type, especially in cold weather, attacks the interdigital spaces and in the folds of the fingers, the nails travel up the arm and the worker suffers from nervous symptoms.

The nails are also affected, and a lesion of the periungal groove leads to the loss of the nail. If the worker suffers from warts these often become a central point of necrosis.

Mechanical work, which is steadily ousting manual work will soon succeed in eliminating this cutaneous disease.

The German factory inspectors, in their report for 1920, refer to a case of dermatitis affecting a worker who had manipulated lemon wood. It is possible that the lesion in question was due to the oil contained in the wood.

Hygiene

Perfume and essence factories are only included among scheduled trades by reason of certain dangerous features (smells, danger of fire where volatile solvents are handled, etc.). On this account they are
subject to certain regulations which will be found detailed in the articles "Odours", "Chemical Trades", and in the articles dealing with the products in question. Where the odour given off is faint and such that it does not constitute a nuisance for the neighbourhood, the workshops may simply be provided with a louver having blade shutters or small chimney stacks raised above the roof. It is, however, advisable that such chimneys should be brought to a sufficient height and turned so as to avoid inconvenience for the neighbourhood and for the factory workers (re-entry of the emanations by windows and doors, etc.). Treating the materials which liberate odours should be effected in closed vessels. It would also be advisable to have the apparatus covered with hoods connected up to a system of localised ventilation in order to remove the fumes. Very often there is every advantage in collecting and recovery of these products (solvents).

The same holds good of operations which involve manipulation of dusty materials or powder.

Cleanliness of workshops and tools should be observed. The workrooms should have impermeable flooring with tiled or cemented yards. Withdrawal of liquids from the workrooms should be effected in waterlight and subterranean piping leading directly to the drains or, where necessary, into vats for treatment. In the absence of drains in the neighbourhood, the liquids should be collected in waterlight vats where they can be neutralised and freed from odours. They should be evacuated as often as possible.

Wherever necessary there should be a provision of water under pressure and facilities for attaching flexible hose to the pipes.

Openings giving on to public highways or neighbouring property should be kept closed.

Measures of personal hygiene are necessary. Certain authorities insist on the necessity of organising a medical service in establishments for the production of artificial perfumes, with compulsory notification of all cases of sickness, even slight. The American enquiry has revealed the importance of medical examination on engagement with a view to elimination of workers affected with certain symptoms or diseases. This is reflected in a notable diminution of the sickness rate of the worker.

Legislation

In Belgium young persons under sixteen years of age are excluded from the manufacture of eau de Cologne and similar products obtained by distillation. For legislative provisions see articles quoted above under Hygiene. See also articles dealing with compensation of injuries due to products manipulated. In Italy compensation is provided in the perfume industry for injuries caused by benzene and its homologues.

Bibliography

See quarterly publication of the International Labour Office: Bibliography of Industrial Hygiene.

Personal Hygiene


The Workers' Health

It is true that factory work is regulated by laws, orders and regulations; but there is no doubt that an understanding based on co-operation and mutual confidence between employer and workman will make this work profitable, remunerative and as agreeable as possible. A factory owner should make a point of introducing all improvements required to ensure both the smooth working and efficiency of his undertaking and for the well-being of his personnel. In this connection it is important to note how anything which contributes to make time spent at the factory agreeable, or which makes the work easier in one way or another, exercises a beneficial influence on the moral of the workman and on output.

The workman feels more at ease and works better in a clean place, well-equipped, spacious and well-lit. For this reason, therefore, it is essential to take special care with the upkeep of the works. It is not enough for the various installations prescribed by regulations to be provided; they must also be maintained in perfect working order. In large works the maintenance, supervision and control of hygienic arrangements should be entrusted to responsible persons.

The workman on his part should feel that some interest is being taken in him; this will encourage him to work. The employer should not strictly confine his solicitude to the works; he should turn his attention to the problems which particularly interest his workmen, and should interest himself in their homes, diet, leisure, children's education, etc. (see article "Welfare").

The formation of joint committees which include representatives of the employers and workmen will do much to bring them
closer to each other in this way, and also to smooth over many differences.

As regards medical examination, see article "Factory Surgeons." The workman must be convinced that all hygienic measures are intended to promote his well-being and efficiency, and that therefore it is entirely to his interest to comply with them.

The buildings should be plain, in good taste, but free from any useless display, as the workman who is obliged to live in modest conditions in his home, does not as a rule like the sanitary accommodation at the works to be on too luxurious a scale.

**DRINKING WATER AND BEVERAGES IN THE WORKSHOP**

Every industrial concern must supply drinking water of good quality and in sufficient quantity for the use of the personnel. The supply of water and its distribution, being a matter of the highest importance, should be considered before the opening of the works.

The drinking water should satisfy certain physical, chemical and bacteriological conditions, which are laid down in each country by the competent authorities.

It must be limpid, colourless, fresh, odourless, tasteless, and not liable to putrescence; it must contain air in solution, and a certain proportion of salts, but must not contain pathogenic micro-organisms.

Water of which the supply is not controlled by some responsible public health service must never be used. Special precautions must be taken in the case of well water, especially in the case of shallow wells. The most scrupulous care must be taken with their construction, so as to ensure purity of the water. All wells must be completely covered and supplied with a fixed device (pump) for raising the water, or with a delivery apparatus which cannot be contaminated.

If the factory must use rain water, collected in cisterns, care must be taken that it does not contain dust, organic matter or dissolved substances coming from zinc or lead roofing. Cisterns must be constructed of water-tight masonry, or of such metal as cast-iron, protected by a paint based on a harmless pigment.

The water supply is sometimes undertaken by the town and sometimes by authorised companies. In order that there may be sufficient pressure, the water is often collected in tanks placed on columns, or on other constructions; in such cases the precautions mentioned above for reservoirs must be observed.

Taps should be placed near the lavatories, and at various points in the workshops to which workers can easily have access, without interfering with their comrades or the general work.

It is also important to put up notices over the water taps, "drinking water" or "washing water not drinkable." Each place for drinking water should be provided with a tap. It is usual to place a metal cup, attached by a chain by the side of the taps; but this custom should be prohibited since it is well known that workers have some repugnance to using the same vessel. Taps and outlets should be so arranged that workmen cannot drink from the spout. Hence the type of fountain with a rising jet is growing in popularity.

Practice has shown the advantage of fountains in which the jet of water is directed from below upwards with a slight inclination towards the front. In this way the water is not contaminated by the drinker who can imbibe it without touching the apparatus. Sometimes a lever enables the height of the jet to be regulated (figs 57 and 58).

Care should be taken to ensure that the water always has a constant temperature, neither too hot to be unpalatable, nor cold enough to cause colic and cramp of the stomach.

No reservoir or receptacle so placed in a workshop that it may be contaminated by dust or fumes should be allowed. When the water which the firm provides does not come up to the desired standard, recourse must be had to purification. Water which is purified artificially should be submitted to constant testing; but a supply of water from an irreprouachable or fixed source is naturally preferable to a suspected supply which has to be purified.

**Methods of Purification**

Among the methods of purification used at the present time are boiling, filtration and chemical processes. Boiling is a process of very limited application; boiled water is free of pathogenic micro-organisms, but it is flat. Neither does filtration represent an ideal and safe process. A bacterial filter abstracts impurities and micro-organisms from water for a certain time, which varies in length according to the kind of filter and the quality of the water; but after this the filter does not function and has to be renewed or cleaned. The best chemical disinfectant in use at the present time is chlorine, which is used in the form of cylinders of liquefied gas, or of hypochlorite of lime, or of other chlorated preparations which give off
chlorine in the nascent state. The bacteriocidal effect of chlorine is very powerful: 1 mg. and even less is sufficient to purify a litre of filtered water after contact in half an hour. If the water is turbid, the quantity of chlorine must be increased.

This method of purification, which is already very extensively used in America, can be used when good drinking water is not available. A good practical means of making drinking water safe without altering the taste is by the use of chloramine. The ozone apparatus should also be mentioned, which, if well constructed, is excellent for purifying water. But very strict supervision is required and the water does not become clear. For this reason the water should be subsequently filtered in order to deliver it pure and clear.

Sterilisation by ultra-violet rays is simple, not costly, and represents the method of the future. However, the sterilisation of large volumes of water has not yet been technically perfected.

**Beverages in the Workshops**

Workmen in general and particularly those in certain industries, such as dusty occupations, those involving exhausting work and work in overheated places, consume, sometimes to excess, drinks such as wine, beer, cider, infusions and coffee, rather than fresh water.

In some occupations, for example in the erection of Flemish furnaces, according to Bargeron, a litre of gin a day at 50° was supplied by contract, and the workmen imbibe it without any drunkenness occurring, though a normal individual employed on less arduous work could not take such an amount without ill-effects.

The fight against alcoholism (see article "Alcohol: Intoxication by") should be carried on with a defined objective; fermented or alcoholic drinks should be replaced by other beverages, non-alcoholic and cheap. Some managements provide tea or coffee gratuitously for their personnel. In other works fruit syrup drinks, milk or lemonade are brought round at fixed hours; for these the workman pays by a check which he buys cheaply at the canteen (see also article "Welfare Workers").

Thus it is seen that a good method of fighting alcoholism, and one worth imitating, is to provide workmen with beverages in the workshop, especially during the summer.

Among these beverages should be mentioned weak cocoa, lemon juice, extract of liquorice, an infusion of the dried leaves of the ash tree, which coloured with caramel and with a little tartaric acid added gives, according to Bargeron, excellent results. A fermentable sweet wort can be made by using ordinary sugar, in an amount varying according to the degree of alcohol to be obtained (18 grm. per litre and per degree) which is started to ferment by means of a few hundred grammes of good yeast.

In Germany efforts are confined to aerating water by means of an apparatus similar to that used for preparing aerated lemonade.

**Legislation**

All laws on the hygiene and safety of workmen call for the provision of drinking water at the place of work. Apart from general regulations and by way of illustration, it may be men...
in Germany, 1911, Belgium and Denmark, 1912, Great Britain, 1911, and the Netherlands, 1906; for building yards in Austria, 1909, and Italy and Switzerland; in the painting, lacquering and decorating trades in Austria, 1908, Belgium, 1910, Great Britain and Russia; in the polygraphic industries of Austria, 1911, and Denmark, 1908; in boot factories in Denmark, 1906; and in bakehouses in Denmark, 1912.

Many Governments have prohibited the introduction and use of fermented and alcoholic drinks in workshops and factories, especially when the workmen are exposed to risks from poisoning. This prohibition, conceived in the interests of the worker's health, as well as in the interests of the employer, has been laid down either by general regulations or by regulations relating to particular industries as follows: in Germany, for the tinning of metals in 1909, enamelling on metal and glass, in the factories of nitro and amino derivatives, and in the pottery trade in 1913; in Italy, in all industrial concerns (section 23 of the General Regulations on Factory Hygiene of 1957); in the Netherlands in compressed air works and in match factories in 1919; in Switzerland by the Federal Act on work in factories in 1914; similarly by the Decree of Luxembourg respecting the health of workers; and in Belgium the Regulations of 1905 concerning the health of workmen.

**PERSONAL CLEANLINESS**

Cleanliness is the basis of hygiene at home, at school and in the workshop.

Fig. 59. — Wash basins in a British factory (Scottish Shale Oil Company, Broxburn).
presides over most organic exchanges; especially if one remembers that a dirty skin may be the starting point of infections and even of serious diseases.

**Lavatories**

Lavatories always include a basin and a tap supplying clean water. Basins in a general lavatory are replaced by a fairly large trough which collects the dirty water after men have washed under a running tap. The dirty water is conveyed outside by suitable pipes.

Tip-up basins that enable the dirty water to be emptied into a trough, are easier to clean than fixed ones.

However, in actual industrial practice troughs or basins are preferred without plugs. In this way the dirty water cannot collect in the basin.

Ordinary buckets or basins without supply taps and without waste pipes should not be regarded as washing places.

The number of taps should be in proportion to the number of persons who have to use them, so as to enable the workers to wash quickly without waiting too long.

The proportion generally adopted is 1 to 5, but this proportion means that only 20 per cent. of the workers can make use of the lavatories at any one time. This proportion is insufficient and a tap for each individual should be aimed at.

A suitable washing place should consist of a basin measuring 50 by 30 by 10 cm., above which, at the level of the hands, is a tap giving a continuous flow of water. The basin should be provided with a waste pipe which cannot be closed (figs. 59, 60 and 61).

If a general lavatory is adopted, each basin should be assigned to definite workers, always the same, so that they wash in turn at the end of each period of work, the time for this being allowed.

The assigning to each worker of a numbered washing place has given very favourable results in practice.

As regards the shape of the basin, there are no rules. It depends on the nature of the work and the local conditions. Generally a basin or deep trough, wide in front is used to enable the upper part of the body to be washed easily, which is very desirable for workers in dusty occupations.

To induce the workers to use the lavatories regularly they should be placed near the workshop, carefully arranged and kept in a clean state. They should be either in the workshop itself or in a place close at hand and should be well lighted, ventilated and warmed in winter, and there should be separate accommodation for the two sexes. If natural lighting is insufficient recourse must be had to artificial light.

The floor should be watertight, of asphalt, flagstones, concrete, or preferably of impregnated wood.

Hot water should also be supplied for the worker, especially if he handles greasy materials, varnishes, fine and adhesive dust, or poisonous materials.

The soap should be supplied by the works; it may be in pieces, or soft or liquid soap, or even soda, pumice-stone, sand, or sawdust. But care should always be taken not to supply soap which is too caustic for workers whose skin has been already irritated by the products handled. In this case recourse should be had to very fat soaps or to other products, such as grease or vaseline.

Each lavatory should be provided with an adequate number of nail brushes, especially in works where there is a risk of poisoning. Some experts also recommend the use of files for the nails.

A towel, used by all and sundry, is not inviting. A separate towel being certainly preferable; but it is costly and has disadvantages. One might even say that supplying individual towels is not, as a rule, indispensable, except in the case of industries with special dangers where personal cleanliness is of fundamental importance.

It has been found at factories where a separate washing-place is provided for each workman, that many make a habit of bringing each Monday, not only their own clean towel, but also a piece of soap.

When lavatories are intended for women it is a good thing to provide looking-glasses. This addition is most acceptable; and it encourages the women to use the lavatory. If no looking-glass is provided it is usual to see women bring little hand mirrors. The toilet is most often made some minutes before the end of work, when supervision is usually relaxed. The woman tidies her hair and powders her face; she ceases work and does not realise that this toilet, done on the quiet and hastily, close to the running machines, may have very serious consequences — as when a scalp is torn off owing to hair getting caught in moving gear.

Bodily hygiene should also include care of the mouth, teeth and nose.

The hygiene of the mouth leaves much to be desired. The article dealing with the teeth and buccal cavity mentions
the occupational injuries caused by vapours and deleterious dust. In some concerns a dental service has been organised (see article "Factory Surgeons"), which is provided by a dentist whose duty it is to inspect the teeth and buccal cavity of each worker at regular intervals. This service is even compulsory for workers employed in certain unhealthy occupations, such as manipulating phosphorus, radium and mesothorium. Many sickness insurance societies include care of the teeth of the insured in their benefits. Inspection by the dentist attached to a factory is essentially of a prophylactic nature, as in the case of the doctor.

**Legislation**

The provision for workers of lavatories in sufficient number in a part of the factory sheltered from dust is laid down: by the German Government in the Factory Code, which also prescribes the provision for workers of nail brushes, soap and hand towels, in lead and zinc foundries, accumulator works, paint works, in works for vulcanising india-rubber articles, for making cigars, alkaline chromates, basic slag, and printing type; by the Austrian Government in the Order of 23 November 1905; by the Belgian Government in the General Regulations for the protection of the health of workers, 1905; by the Danish Government, as regards boot factories, bakeries, printing works, iron foundries and laundries; by the French Government in the Factory Act and Regulations for operations of combing and carding wool, hair, bristles and Indian wool, for white lead works, works for the manufacture of lead compounds and the vulcanisation of india-rubber, for brass foundries, file works, and works for enamelling on metals, for pottery works and chromate works (generally the requirements on this matter are very detailed); by the Italian Government in sections 19-20 of the Regulations for the health of workers of 1927; by the Governments of the Netherlands, Sweden, and Yugoslavia in the Regulations of 1921.

**Douche Baths**

Men and women employed at factory work require baths, and the more so in proportion as their work calls for great muscular exertion, or as it is carried on under unfavourable conditions of heat and dust. The lavatories provided in some industries do not allow the workers to pay sufficient attention to their personal hygiene; hence it would be well if most, or better still if all, industries provided douche baths. The simple douche is to be preferred to the bath-tub; it is much cheaper and requires less maintenance. In some firms both systems are put in; and the worker has a right to three douches a week and to a full bath each month. For certain classes of workers who are employed at furnaces or in overheated places, or who handle poisonous materials, a daily douche at the end of each day's work is necessary. Douche baths should supply cold water (18° to 24° C.), tepid (25° to 30° C.) and warm (30° to 35° C.) for the different requirements.

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Compartments of 1 by 1.20 m. or less should have walls covered with a layer of very smooth impermeable cement;
the floor should be slightly on the slope and impermeable; some pegs for hanging clothes should be fixed at the door and a seat of hard wood provided. These places should be well ventilated and lighted and heated in cold weather (fig. 17).

Douches and baths should be placed in separate compartments, divided by thin metal partitions 2 m. high. For douches the compartment should be divided into two by a partition so that the clothes are not splashed by the water. If natural lighting is not sufficient a good lamp should be put in, which will light both parts of the compartment.

A certain number of bath tubs should also be provided for cleansing purposes. Such a room should have a minimum area of 2 by 1.40 m. The waste pipe of the bath-tub should be connected by a water seal or trap with the collecting pipes. The bath-tub should be well made in white enamelled iron so that it can be easily kept clean. One or two baths should also be attached to the works ambulance room.

For most workers douche baths are sufficient to ensure personal cleanliness.

A rose sending out tepid water should be used, the flow of which can be stopped at will by the person using it.

The flow from the douche should fall in a fine spray which is slightly slanted. For women a waterproof cap will protect the hair. But the rose may be replaced by a metal ring pierced with small holes and connected with the tap by a flexible tube. The ring makes it possible to spray the body without wetting the hair.

The bather should bring his soap and towel; but on premises where serious occupational risks exist, they should be supplied gratuitously by the firm.

The douche bath allows not only thorough soaping, but also a perfect rinsing with clean water.

Douche baths are generally put in by the firm, and, while some employers make a small charge to cover part of the expenses of maintenance, others not only provide them free, but award prizes to the workers who take the greatest number of baths during the year. In unhealthy industries the time taken for the douche or bath is included in the working time, and is paid for as ordinary work. Outside working hours, if the situation of the baths allows, it is good practice to place them at the disposal of the workers’ families.

During the summer, where it is possible, douches should be replaced by bathing in the running water of a lake or river.

As regards the provision of covered swimming baths, see article “Welfare”.

Legislation

The same rules requiring the provision of lavatories for workers as a rule also require the provision of douche baths with soap and towels. Sometimes, even the intervals at which baths are to be taken are fixed for persons employed in particularly injurious processes.

Douche baths are required to be provided by the following Governments: in Germany by the Regulations relating to the industries dealing with leather, hair, brushes and hair pencils (1905: twice a week), for lead foundries (1905: daily for certain classes of workers, weekly for others), for accumulator factories (1908: weekly), for lead colour works (daily), for alkaline chromate works (1907: weekly), and for basic slag and nitro and amino compounds works; in Austria for lead and zinc foundries, sugar refineries and paper works; in Belgium for works producing white lead and other lead compounds (1910: a douche bath for every five workmen); in Denmark for bakers and confectioners (1912); in Great Britain in white lead works (1899: daily), accumu
lator works (1903), in lead smelting and the manufacture of red lead and litharge (1911), and nitro and amino derivatives works; in Italy (1927) for works with more than twenty workers when the work is dusty or gives off fumes or foul vapours, or when poisonous materials are handled; in the Netherlands, for mines (1906) on leaving the mine; and also in Belgium, in Hungary for the preparation of hair (1905: weekly); in Yugoslavia (Regulation of 1921, section 17). In Great Britain, douche baths at coal mines are being constructed out of a special levy imposed by Parliament.

Clothing, Head Coverings, Gloves and Boots

For most industrial processes the use of such working clothes as blouses, aprons and overalls is advisable. This measure is essential in all works where clothing is exposed to contamination or spoiling by grease, colours or dust, and especially when poisonous substances and dust are manipulated.

Working clothes may be brought by the workman or supplied by the factory. But gratuitous provision to the workers has its disadvantage; a worker who has no direct interest at stake is too ready to neglect what is offered to him; whilst if he is required to pay even a very small part of the cost of purchase and of maintenance, he is more careful. On the other hand, inspection and maintenance are easier if the factory has charge of the provision.

Light colours are to be preferred for working clothes, because the state of cleanliness is then apparent. For women, aprons with sleeves, but without frills or ornamentation, should be chosen. Loose strings and ribbons must be avoided. In factories with motors and driving belts, button-holes should be put on the side or covered in such a way as to avoid accidents. Further, skirts should be replaced by trousers, wherever the wearing of skirts presents a danger from moving machinery, and especially in places where dust, irritating vapours, or clouds of steam are given off. In these cases working clothes should fit close about the neck, wrists and legs (gaiters); the hair should be protected by means of head covers or washable caps. The use of special coverings for the head is most necessary when toxic dust is present.

No clothing or equipment in celluloid or other highly inflammable substances should be allowed in undertakings where there are fire risks.

The Moscow Institute for the Protection of Labour has since 1926 studied the principles of suitable working clothes, taking into account both the injurious nature of the occupation and the hygienic properties of the materials used. Up to the present, investigations have been made concerning woolen, linen and cotton materials, and india-rubber used to waterproof stuffs, materials used for gloves, leather, etc., for working boots. Naturally, consideration has been given to the weight, thickness, porosity, permeability to water, conductivity and loss of heat and the effect of dust and liquids on the wearing properties of these products (Schafranoff).

Although the wearing of gloves, especially waterproof ones, is not always advisable, as in some cases it increases the injurious effect of the substance against which it is wished to protect the workman, it is nevertheless desirable to recommend the use of india-rubber gloves when the duration of work is not too long. Whilst india-rubber gloves are useful to protect the hands against the irritating
or poisonous effect of materials, in other cases it is preferable to use leather gloves. These, and also mittens made of coarse linen, have the advantage of costing less and of being easily washed. In some occupations suitable shoes should be supplied to the workers. This is the case with foundry workers, where the wearing of old boots or shoes explains the very high number of accidents caused by burns on the feet and toes. The indifference of workers in certain occupations has to be overcome and they have to be convinced of the necessity of wearing sufficiently thick leather boots which have suitable soles and heels.

Fig. 64. — Lockers in a Swiss factory (Sulzer Works).

With wet floors, such as are found in dyeworks, clogs are preferable. In some cases the use of non-inflammable asbestos stockings or socks is to be recommended. Men working in water are obliged to use boots of India-rubber or leather so impregnated as to be impermeable.

Wearing rubber gloves, clothing, or boots too long at a time must be avoided.

Legislation

The Governments of the following countries have made regulations which require the free issue of working clothes to workers, their maintenance and periodical washing: Germany (Order relating to factories where rubber articles are vulcanised); Prussia (Order relating to picric acid works); Austria, Belgium and France (the use of white lead in painting, factories for copper acet-oarsenite); Great Britain (combining and carding of wool and hair, spinning and weaving linen, the use of East Indian wool, accumulator factories, paint and colour works, smelting of substances containing lead, the manufacture of nitro and amino derivatives, and of alkaline chromates); Hungary (the preparing of animal hides); the Netherlands (work in mines). Impermeable aprons are required, for example, in Great Britain in the tinning of metal, the cutting of files by hand, and the pottery trade. Gloves must be supplied in Austria to workmen employed at certain operations in zinc and lead smelting; in Germany, in lead-smelting foundries, lead colour works, the polishing of metals, and the manufacture of nitro and amino derivatives; in France, in industries with a risk of lead poisoning; in factories for copper.

Working caps are chiefly required to be provided for operations giving off dust, in the spinning of horsehair, other animal hair and silk (Germany, Belgium, Great Britain and Hungary); in industries with a risk of lead poisoning; in works manufacturing white lead, colours, pottery, accumulators, in lithographic printing works, and enamelling works (Germany, Austria, Belgium, France and Great Britain); in works for alkaline chromates, works for nitro and amino derivatives, or where there is a risk from exposure to anthrax infection (Germany, France and Great Britain). Some Governments also make it compulsory for employers to undertake the drying of clothes moistened during humid textile operations and dyeing.

Special precautions should be taken for cleaning clothes and head coverings which have been worn during operations involving exposure to such dangers as poisoning by lead, benzene compounds, or aniline, or anthrax infection.

Cloakrooms

On entering the factory, as well as on leaving, the worker requires to take off his ordinary clothing and put on his working clothes, and vice versa, as quickly possible. For a long time only coat hooks, simple pegs, and quite often nails, were used for hanging the workers' outdoor clothes, which were thus exposed to dust, splashes from liquids and to steam.

Next it was thought to be enough to hide clothes so hung up behind a sufficiently long curtain. A board was provided for the boots which were thus kept away from the damp of the ground.
A so-called improvement consisted of a sliding door which replaced the curtain and transformed the cloakroom into a kind of general wardrobe. It was found at once that this system gave rise to danger of contamination; that it led to an offensive smell; that it required supervision by some responsible person since it cannot be kept shut.

Hence, only the separate clothes lockers, now so largely used, are to be recommended as the best solution of the problem.

They are made of wood protected with a coat of paint, or still better, of smooth sheet iron, with a door, fitted with a grating for inspection of the inside and for ventilation. The lockers are generally arranged in groups of four or five or more, and sometimes even in two stories.

The door must be closed with a padlock; otherwise the workers will distrust the lockers (figs. 63, 64, 65).

The locker should have one or several hooks inside, a shelf for putting boots on and another at the top for the worker to put his dinner on. A very simple arrangement allows of an umbrella being placed against the inside of the door.

In unhealthy trades, the workers should be provided with a locker having two compartments, one for outdoor clothes and the other for working clothes.

In new buildings, the cloakroom should be separate from the workshops, warmed in winter and situated in the same place as, or quite close to, the lavatories and douches (figs. 66 and 67).

Sometimes, principally in the mining industry, the clothes are hung on a bar and raised to the ceiling by pulleys during the working hours. This system has the advantage of avoiding thefts; but the workman prefers his cupboard with a key or padlock.

When the working clothes are dusty or covered with grease or poisonous substances, it is much better to hang them in the open air rather than shut them up, and to keep the lockers for the clean outdoor clothes.

Legislation.

As a general rule working clothes should remain at the factory. This rule is especially important in the case of unhealthy and poisonous trades.

Cupboards or cloakrooms, placed in a special part of the factory, separate lockers with one or two compartments, a lock and a ventilating opening, etc., are required by laws prescribing the provision or use of working clothes and head coverings.

In general it may be said that Governments, which have enacted measures for
the provision of lavatories or douche baths, and the supply of clothing for workers, require also the provision of lockers and cloakrooms, especially for industries with special risks or particularly dusty.

**Privies**

An installation, without useless luxury, but quite complete, is of the highest importance. Privies should be placed quite close to the workplaces, with which, however, they should not communicate directly, but should be separated by a corridor or vestibule. In large factories, privies are sometimes placed in small, separate buildings and are for the use of the different departments of the factory.

A privy includes a seat of special shape, a flushing pipe, a cesspit or a connection with the principal sewer. A privy should be so arranged that it (a) permits of the easy accomplishment of the function for which it is made; (b) is easily kept in a state of cleanliness; (c) is not liable to annoy the user by the escape of sewer or irrespirable gas; (d) does not allow these gases to spread into the working places.

Abba, of Turin, has studied the hygiene and structure of sanitary apparatus, hitherto constructed on empirical lines.

Simple analysis easily shows up defects of construction or working as well as the ill-effects which they may cause.

Persons who use privies can be grouped into a majority who sit over the pan, and a minority who squat; the latter, on this account, have to stand upon ordinary pans, thereby soiling them. Hence pans have been constructed with places for the feet on the sides, which enable these persons to squat without coming in contact with the pan.

It must be admitted that a large class of persons exists who do not appreciate that closets are, and should be, the cleanest parts of a house, factory or office.

The Romans studied the physiology of the act well and constructed seats which, as can still be seen at Pompeii,
are certainly rudimentary; requiring much water, but in keeping with the teaching of modern physiology, according to which water is the only disinfectant for closets.

The idea which predominated all through the Middle Ages is still embodied in the Turkish type of closet, represented by a slab of stone, or more rarely of wood, flush with the ground, with a central circular opening of about 20 cm. diameter, and either with or without a cover. But the circular form of opening does not ensure the evacuation of the excreta which spread over the slab and the ground. As a matter of fact, if the physiological act is observed, it is found that the directions of micturition and defaecation are divergent and that the opening consequently should not be round, but should take the shape of a long fissure narrowing from back to front (fig. 68).

If the squatting attitude, the abolition of the seat, places for the feet, and a flush of water are the indispensable principles for the construction of a practical hygienic closet, certain details of no less importance must still be taken into account.

The places for the feet should not be too low, nor too sloping, nor so slippery as to give the user a feeling of insecurity; the footplaces should be divergent and not parallel; the opening should be of the shape previously mentioned; the flush of water should not be automatic, for it might occur at an inopportune moment and wet the user.

When the pan system is adopted a type should be chosen which receives the excreta without any going on the floor of the closet. The type studied by Risso and constructed by Abba resembles a gondola in shape, 60 cm. long and 20 cm. wide, raised at the two extremities so as to facilitate the flow of excreta into an outlet opening of 10 cm. diameter (fig. 69).

In the case of a series of pans Abba does not advise a hydraulic flush for each pan, but a common flush for the whole series. Each pan discharges the excreta through a short pipe which dips into a collecting pipe filled with water.

The writer holds that as far as men are concerned the Turkish closet is preferable. In this case the seats are generally made of iron sheets, or slabs of cement or ceramic tiles. The water flush is then automatic, although this scheme is not very economical; but the type of flush depending on the user...
does not give satisfaction, as for various reasons it easily gets out of order.

In the case of outdoor privies a type of collective privy is represented by a series of closets made in cement, traversed by a channel, over which the users place themselves astride, putting their feet on the places marked for them. Every ten or fifteen minutes an automatic flush releases 20 litres of water in order to keep the channel cleaned out. The channel, of course, will be on a slope, to ensure good drainage, and must be cemented and impermeable (figs. 70 and 71).

The very common method of overcoming offensive smells by sprinkling the floor, the seats and pans with chloride of lime or other disinfectant, is, according to Abba, only one of many modern hygienic frauds.

Closets must be kept clean, even against the will of the users, and this method is only employed to excuse the carelessness of persons who ought to be clean, and of the staff entrusted with the supervision of the closets.

The offensive smell of excreta should not be replaced by a stronger one which only masks it, but the place should always be in a constant state of cleanliness; water, a broom and a little work are all that is needed to attain this end. But it must be constantly borne in mind that kitchens and privies are the parts of a building which should be kept cleanest.

Urinals are also of several types: slabs, troughs or basins with or without a water flush. Clearly in this last case they are open to criticism and should not be adopted.

Urine is a liquid which is responsible for most of the foul smells of closets. It rapidly ferments and gives off ammoniacal vapours which persist till the urine has completely evaporated.

The floor should not soil the walls or floor of closets or urinals. Unfortunately it happens too often that not only the floor in front of the slab is soiled with urine, but even further back, which increases the surface giving off foul smells.

In order to overcome this nuisance the person should be obliged to approach as close as possible to the urinal, so that the last drops of micturition fall into the receptacle. Hence the most appropriate type is that represented by a porcelain basin fixed on the wall at a suitable height, with the front part in the shape of a beak. This form, however, while it is suitable for private houses or offices, is not to be recommended for places used by persons who are less careful of cleanliness and do not take the necessary precautions not to soil the floor. In these places (factories and public urinals) a type with marble slabs or iron sheets may be used with advantage; these slabs should reach down to the ground, with a channel level with the floor, the front part of which should be in the shape of a beak, extending to the heel of the foot rest, which must be raised sufficiently above the floor. In this way the person is compelled to stand on the foot rest.
and the last drops of urine will not fall on the floor (fig. 72).

Cleansing of the surface of the urinal may be ensured by a simple channel with water running all along the upper border of the slab, over which it spills continuously.

This system ensures, better than any other, automatic flushing and the cleanliness of the urinal.

The most common type of slab urinals are usually made of marble, artificial stone, shale, or slate; those with a trough are made of glazed earthenware or iron coated with enamel, or, only too often, with zinc, which is very difficult to keep clean.

The care of privies, like that of lavatories, should be entrusted to a responsible and conscientious person. It should be borne in mind that the workman submits to regulations much more readily if clean, well-cared-for closets are provided for him; whilst, on the other hand, a model installation, if not properly cared for, loses its value.

Special mention should be made of movable receptacles or tubs which are used chiefly for underground workings in mines and tunnels (see articles "Ankylostomiasis" and "Mines: Hygiene in ").

It will be sufficient to say here that if movable tubs are well arranged they form quite a practical system; but they must, be quite watertight, removed regularly by a responsible person, and washed, or, if necessary, disinfected. The receptacles should be very strong, with well-fitting lids, shutting closely so as to avoid any spilling during transport, and should be made of metal in order to prevent impregnation by faeces and urine. Drain pipes for the outfall should be wide and smooth.

The tubs should be placed where they can be easily got at, or should be mounted on rails to facilitate their removal and emptying.

The lid fitted to the receptacle may be arranged so that each time it is closed it scatters over the faeces some such deodorising material as powdered peat, iron pyrites or lime. This system, however, requires much attention.

It is not necessary here to enter into details for the construction of fixed cesspools where no drainage system exists. Ordinary cesspools, septic or...
biological purification tanks belong to the public health department; and any arrangement of this kind should accord with the scheme adopted by the local public health regulations.

Legislation

Regulations generally require privies to be provided in numbers sufficient for the needs of the personnel. They must be separate for the two sexes, well looked after and disinfected, ventilated and lighted. Some regulations fix the number at one per twenty-five or thirty. Others at one per twenty or thirty. Some only require separation of closets for the two sexes when the number of persons working at the factory is more than five, ten, or even twenty. Working regulations for mines lay down very detailed rules for the arrangement and maintenance of movable tubs and cess pits, either on the surface or at the pit bottom.

Some regulations, concerned with work at hot and damp processes, such as in sugar refineries, paper works, and humid weaving sheds, lay down that the closets shall be arranged so that they protect the workers against too sudden changes of temperature and against inclement weather.

Spittoons

The habit of spitting on the ground is ingrained almost everywhere. In order to overcome this bad habit at the factory, as in the streets, people must first be educated. In various countries the authorities, as well as anti-tuberculosis associations, have published notices or rules forbidding spitting on the ground.

Spittoons at factories ought not to be necessary. But if it is necessary to suggest a practical type it must be admitted that none of those recommended is ideal. Spittoons have been made with covers and a water flush; as soon as the cover is raised the tap opens and water cleans the inside of the spittoon. Others are only open basins, hung on the wall at a suitable height, in which water circulates permanently over the interior surface. The use of spittoons of paraffined cardboard has also been recommended; they contain peat or sawdust impregnated with formol. The sputum is thus absorbed; and the cardboard boxes are periodically collected and burnt.

This system is certainly economical, but it requires strict supervision; moreover, the cardboard boxes are very fragile.

Types of spittoons placed on the ground should not be recommended, as drops strike the ground or against the wall. This in itself gives us some indication of the proper place for a spittoon. In addition the spittoon should be closed. If an enamelled metal or earthenware type is used, hung on the wall at 50 cm. or 1 m. from the ground, it is better to fill it with water, soda, or a solution of soap with cresol, rather than sawdust or sand, which dries up too quickly.

Another problem, which in practice is fairly difficult to solve, is the number and situation of spittoons required. It is not possible to arrange them conveniently for all persons who possess the bad habit of spitting, especially when the place is filled with machinery. As for some individuals spitting is a natural necessity, it would be better to arrange for them to use the privies;
but this requirement is somewhat exaggerated. The difficulty can only be overcome by teaching each individual how to behave.

The ideal would be to use pocket spittoons. It is certainly necessary to forbid spitting on the ground; and those who spit, whether sick or not, should be convinced that they ought to provide themselves with pocket spittoons and should look after them themselves.

Legislation

Several regulations have laid down that spittoons are to be provided in workshops and in dormitories attached to building yards. It will be sufficient to quote here the rules adopted by the Italian and Yugoslav Governments: "Spattoons in sufficient number containing a liquid must be placed in all workplaces. Spittoons must be washed out daily" (section 12, Yugoslav Regulations of 25 October 1921). "Employers must provide in workplaces, staircases and other passage ways, spittoons, which must be cleaned and disinfected in an adequate manner. In the workplaces and passage ways in question workmen must use the spittoons provided for them" (section 22 of the Italian Industrial Hygiene Regulations, 1927).

Seats

The standing position is tiring when prolonged; it weakens the attention, makes for painful flat feet, varicose veins, and, in women, affections of the pelvic organs. On the other hand the sitting posture is also fatiguing if prolonged. Roux (Lausanne) is quite right in stating that a child is an expert in changing: the same can be said of workers. Change of position gives rest; hence it should be arranged that persons who work standing are able to sit, and inversely that workmen and workwomen who work seated can from time to time stand up.

For workshops, as for trading shops, certain rules prescribe a number of seats equal to the number of persons employed. The wisdom of this rule is universally recognised; but its practical application leaves much to be desired. The number and duration of rest periods when workmen and workwomen obliged to work standing are able to sit vary a good deal.

For persons employed on machines in continuous motion an interruption of work has been proposed in the light of comparative experience. It has been found that the daily output increases from 6 to 10 per cent. when a rest of five minutes an hour is allowed with the possibility of sitting down. Here is an important point: the interruption of work increases the output, instead of diminishing it.

In the choice of seats several factors should be taken into consideration: operations in which the worker can do his work sitting; operations in which the worker can from time to time rest and sit; and the advisability of providing seats outside the workrooms during rest periods.

For work which can be done in the sitting posture the type of seat to be chosen depends naturally on the kind of work. The seat should be well designed and well placed, so that the workman is not forced into a bad attitude, which in the long run may cause disorders of the digestive organs, the abdominal organs, or even lead to deformities.

The shape of the seat, then, should be such that it will allow a normal and healthy position, quite freeing the legs from the weight of the body.

If the position of the piece to be machine cannot be suitably changed, a seat adjustable by the worker should be provided. The construction of these seats should be based on the principle that the elbow of the worker when seated at work should be at the same height as if he was performing the work standing.

In addition, the seats should be easily movable so as not to be in the way of a worker who wishes sometimes to sit at work and sometimes to stand; but they should be fixed to the floor if the machinery is dangerous.

Seats should be supplied with a back, which should be suitably sloped back and high enough to support the lower part of the back of the worker.

In some cases it is preferable to regulate the height of the table or of the working bench rather than that of the seats.

Seats should be provided with foot rests if they are very high and do not permit workers to place their feet on
the ground. If the floor of the workplace is subject to vibrations or to shocks, spring seats or seats with rubber pads on the feet should be used.

As regards operations of the second group, that is when the worker can rest from time to time, the machine only requiring such supervision as can be exercised while seated, the seats can be boxes, or better, chairs or forms placed along the walls. But if the place is full of machinery and workers, it will be useful to arrange folding chairs along the walls, by pillars, or even at the side of the machines.

It should not be necessary to insist on the fact that seats placed in the rooms should answer the purpose in view. Hence simple and practical patterns should be chosen, but especially those which enable workers to rest comfortably.

A good chair is not sufficient. There must be the right relation between the seat, the work table and the support for the feet. The Industrial Commission of the State of New York has formulated the following conditions as essential for a good chair, which should clearly suit the kind of work: the seat should be wide and not too high, so that it does not interfere with the lower part of the body, but not too deep, slightly saddle-backed with the front edge rounded; the feet should rest comfortably on the floor, or on a broad rest fixed to the floor, or to the table. The distance between the table and the seat should be sufficient to ensure freedom for the knees. No bar or other obstacle should interfere with a comfortable position for the feet. There ought to be a back to support the lower part of the body, but not too high, so that it does not interfere with movements of the arms.

Several firms in various countries now sell excellent types of working seats. A worker who works in an abnormal position tires much more rapidly and is more liable to accidents than a worker at ease. This increase of fatigue should be avoided as far as possible; and this can be done in many cases by replacing manual work by machinery. The miner who is obliged to handle his pick lying or crouching on the ground and the house painter engaged on whitewashing the ceiling, with his head held back, cannot keep at work long; more frequent rests should be allowed them and a reduction of the working spell.

Legislation

The Belgian Act of 25 June 1905 lays down that seats are to be provided for saleswomen employed in shops; and similarly the French Labour Code (section 76) lays down that "shops and stores or other places connected with them, in which merchandise and other articles are handled or offered to the public by a female personnel, must have in each room a number of seats equal to that of the women who are employed there."

The Italian Industrial Health Regulations lay down that workers in industrial and commercial undertakings, where the work is not continuous, shall be provided with a sufficient number of seats (section 23).

German legislation requires seats in the rest rooms for workers in building yards and yards for dressing stone. Seats are required to be provided: in Spain by the Act of 27 February 1912; in Finland and the Netherlands by the Acts of 1920; in Austria and Great Britain by the Acts of 1921; in Russia by the Act of 1922; in Argentina and Persia by the Acts of 1923.

Dining-Rooms

Laws rightly forbid persons employed in factories to take their food into the places of work. This prohibition applies particularly to works where poisonous substances are produced or manipulated, or where the operations carried on give rise to emanations which are unhealthy, disagreeable or poisonous, or generate dust, and, as a general rule, when the hygienic conditions are not satisfactory and where the health of workers may be affected.

As a logical result of this prohibition, especially if for special reasons the workers cannot take their meals at home or in a canteen, an obligation lies on employers to provide a dining-room for their workers, furnished with tables and seats in sufficient number.

Legislation

In all the laws examined above, measures are found dealing with the establishment and maintenance of a dining-room. It should be well ventilated, lighted, heated in cold weather, easily cleaned,
of a size in proportion to the number of workers and provided with the means necessary for heating up food.

Access to the dining-room should be arranged so as to compel the worker to pass through the place where the lavatories and cloakrooms are situated.

In some cases it is desirable that there should be several dining-rooms; for example, one for each floor or building, so that the workers do not have to go a long way. This disadvantage explains why in some cases the establishment of dining-rooms has not been appreciated by the workers as much as should have been the case.

The floor should be smooth, impermeable, easily washed down with water; the walls should be lined with ceramic tiles up to a height of 1.50 m.

Care should be taken to avoid giving the place any resemblance to a barrack mess-room or to a school; small tables should be provided with four to six places and seats rather than forms.

The tables may have marble tops or be covered with glazed tiles, which give a more aesthetic appearance; such tiles, moreover, are easily washed. It is also desirable to provide small separate pigeon holes wherein the workers can place the food they bring from home.

An adjoining place should contain apparatus for heating up food already prepared which the workers bring from home. For this there are now quite a number of cookers, employing either steam or gas heating; they should be sufficient in number.

As regards factory canteens, see article "Welfare".

In addition to alcohol, another poison which deserves special mention is tobacco. In the same way as alcohol, nicotine and the toxic substances absorbed with smoke are especially injurious to young persons, or the weak and delicate. Hence, in a number of works and in most of the industrial laws and regulations, especially for unhealthy industries, it is forbidden to smoke or to take snuff during working hours. This prohibition also covers the habit, unfortunately too common, of chewing tobacco, and it should be still more widely enforced, for the introduction of chewing tobacco into the mouth and even the act of putting a pipe or cigarette in the mouth with hands soiled by lead, mercury, or other poisons, facilitates the introduction of poison into the system.

Prof. W. Silberschmidt
(Zurich)

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**Petroleum and Lubricating Oils**


Crude petroleum or mineral oil is found in the ground at varying depths and is obtained by drilling. The pressure of gases accumulated above the oil is sometimes sufficient to cause it to spout up into the air, but it is often necessary to use pumps. The gases which escape from the bore-holes may cause serious conflagrations.

The most important fields are in the United States, Mexico, Russia, Persia, the Dutch East Indies and Rumania.

Crude mineral oils are found in the form of lands of variable fluidity, ranging in colour from a transparent yellow to blackish brown, with a green fluorescence and an allaceous odour. Their density is between 0.766 and 0.975. On burning they give off thick fumes without leaving any ash. They are not liable to spontaneous combustion.

Whilst readily soluble in alcohol, ether, benzene and carbon bisulphide and tetra-chloride, mineral oils are only slightly so in dilute alcohol and are insoluble in water.

From the chemical point of view, mineral oils are mixtures of hydrocarbons, and are divided into two main groups according to the predominance of paraffins (methane hydrocarbons, C\(_n\)H\(_{2n+2}\)) or naphthenes (cyclohexanes and methyl-cyclohexanes, C\(_{11}\)H\(_{22}\)). To the first group belong most of the mineral oils of the United States, while the Russian belong to the second. Some, e.g. those of Borneo, contain large quantities of benzene hydrocarbons.

A third group, containing the hydrocarbons of the two preceding series, is distinguished by certain experts; and in this are included the mineral oils of Rumania and Galicia.

All crude mineral oils contain a large number of impurities, notably naphthas, phenolic and sulphated compounds, organic acids, resinous substances, and pyridic bases. The presence of sulphur (up to 5 per cent.) gives a disagreeable odour and renders refining difficult.

The composition of mineral oil, however, varies widely from one region to another, and even from one bore-holes to an adjoining one.

**INDUSTRIAL OPERATIONS**

**Distillation of Crude Mineral Oil**

Crude mineral oil, which contains impurities from the soil, such as earth, sand and water, is stored in reservoirs, where a large part of them settle. Separation from water is sometimes effected by centrifugal apparatus Fur-
ther purification is carried out by distillation in vertical or horizontal stills, heated either from below or internally by means of pipes, or by introducing a current of superheated steam (Russia) which lowers the boiling point of the hydrocarbons and makes almost complete distillation possible; or again by a vacuum (the Steinschneider Porges process), used chiefly for the treatment of very viscous crude oils. The distillates thus produced in the stills travel to a cooled worm, either directly, or after having traversed a fractionating column, similar to those used for the rectification of alcohol. Each fraction is passed to a special worm, the heaviest fractions returning to the still.

In large plants, distillation goes on continuously in a series of stills arranged one above the other. The mineral oil flows from one still to another, and is subjected to higher and higher temperatures; the residue accumulates in the last still. The condensation apparatus is, in this case, simpler and consists of only a rectifier and a worm.

The dissolved gases set free during distillation are drawn off by pumps and liquefied, either by compression or by being redissolved. Part of these gases, non-condensed, can be used as fuel.

This first distillation of mineral oil gives the following fractions:

<table>
<thead>
<tr>
<th>Temperature of boiling at ordinary pressure</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum ether</td>
<td>45-70°</td>
</tr>
<tr>
<td>Illuminating oils (kerosene)</td>
<td>150-300°</td>
</tr>
<tr>
<td>Light fractions Petroleum naphtha</td>
<td>70-100°</td>
</tr>
<tr>
<td>Mazout (heavy oils, residual tar)</td>
<td>300-100°</td>
</tr>
</tbody>
</table>

The light fractions may contain petroleum ether (see below: Fractioning of the Light Fractions).

The quantities of these fractions vary according to the source of the mineral oils.

Rectification

If the first distillation is insufficient, the products obtained are distilled afresh, in such a way as to split them into a certain number of definite products. The apparatus used is in principle identical with that used for distillation.

The distillation or rectification of light fractions or of benzenes, which are very inflammable, can only be done in stills heated by steam under pressure.

The refining of crude mineral oil, or more usually of certain fractions from the distillation, consists essentially in treatment with sulphuric acid, followed by neutralisation by means of soda lye. In some cases the mineral oil is lixiviated directly with caustic soda, or hypochlorite of soda, in order to decolorise and deodorise the products, to diminish the strength in sulphur, to render them more limpid and less sensitive to the effect of heat and light, and to give them greater illuminating power.

The operation is effected in large receptacles or "stirrers" made of iron, lined on the inside with lead, erected in the open air at a distance from the furnaces, but near the storage tanks and the consignment buildings.

A mixture of acid which has already been used and petrol is subjected to energetic stirring by means of a jet of compressed air. It is allowed to stand; the acid layer is then drawn off; and the operation is next repeated several times, using fresh acid at 60° B. The mineral oil, which is now reddish brown in colour and has a strong smell of sulphurous acid, is washed, and then treated with soda lye to remove the last traces of acid. Direct neutralisation is avoided after treatment by acid since the heat which results might cause combustion. In order to avoid accidents, the gases given off during these operations are continuously removed.

The illuminating oils are further passed through such filtering materials as Fuller's earth, clay or bauxite, which are piled up in large vertical cylinders. The heavy products arrested by the filtering material are recovered by heating in special apparatus.

**Fractioning of the Light Fractions**

Each of the fractions obtained at the first distillation is, in its turn, fractionated to obtain marketable commodities. The light fractions, when redistilled in apparatus heated by steam, give the following products, of which the density varies from 0.600 to 0.750:

<table>
<thead>
<tr>
<th>Boiling point</th>
<th>Boiling point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum ether</td>
<td>45-70°</td>
</tr>
<tr>
<td>Gasoline</td>
<td>70-83°</td>
</tr>
<tr>
<td>Petroleum naphtha: C (petroleum benzine)</td>
<td>80-100°</td>
</tr>
<tr>
<td>Petroleum naphtha: B (ligroine) A</td>
<td>100-120°</td>
</tr>
</tbody>
</table>

There is a commercial product named "Rhigolene" (German, Rigolen) with a density between 0.60 and 0.62, some fractions of which boil below 55° and others above 55° C. It is used for local anaesthesia and as a solvent in freezing machines.
The petroleum ethers and gasoline, which constitute the light benzine of commerce, are colourless liquids with a strong and characteristic odour, insoluble in water, rather soluble in alcohol, and miscible in all proportions with ether and chloroform; they give off fumes three times heavier than air, and cannot form nitrated combinations. In commerce, petroleum ether and gasoline are often substituted for benzene (C₆H₆), from which fact comes the name of benzine which has been wrongly applied to them. Their capacity for dissolving fatty bodies leads to their use for scouring cloth, chemical or dry cleaning, the extraction of animal and vegetable fats (in the place of carbon bisulphide), and cleaning machinery and objects coated with oil; for polishing; and for preparing solutions of rubber (used on pneumatic tyres, mackintoshes and rubber shoes), or of such resinous substances as lacquers, varnishes and ink colours, instead of turpentine. But for the most part they are used as fuel for small motors.

Petroleum benzine and ligroine — known as middle benzines — serve equally for fuel and for dissolving fats, oils and resins. They are also used as cleansers for removal of stains in dry cleaning.

The last fraction, or heavy benzine, is used as a solvent in the preparation of lacquers and colours for printing, and as fuel for heavy engines.

Petroleum naphtha is the dearest of the derivatives of petroleum. For this reason efforts have been made to increase the proportion of light fractions in the crude oils by subjecting them to special processes. One of these, designated "cracking", is the dissociation of heavy oils by means of high temperatures and pressures, e.g., up to 500° C. at 15-20 atmospheres, in the presence of catalysts. The resulting products are the lighter fractions and a residue, which is a heavier oil or a coke. The processes of "cracking" are numerous, but only a dozen have come to be used industrially.

The utilisation of "cracking", improvements on ordinary methods of refining, and the extraction of light fractions from natural gases have led to a considerable increase in the production of petroleum naphtha. "Crack-
ing" has, moreover, made it possible to treat the heavy oils from certain districts, previously not distilled on account of their high sulphur content.

The other process, hydrogenation, is carried out generally at about 400 to 500° C., either at ordinary pressure in the presence of such a catalyst as iron or reduced nickel (Sabatier and Mailhe), or at pressures raised as high as possible (Bergius and Klung). It furnishes liquid hydrocarbons with quite low boiling points, the percentage of which may amount to 15 or 25 per cent.

It is worth mentioning in passing that the reproduction of mineral oil by synthetic means has been tried, either by direct hydrogenation of acetylene on nickel at 200° C., or with water-gas, or by the distillation of such fatty substances as whale oils.

In the refining process it is important to mention the operation for recovering agents from the spent solutions of sodic plumbite. The solution, which contains about 0.6 per cent. of PbO (in solution as sodic plumbite), 4 per cent. of PbS in the sludge, and 11 per cent. of caustic soda, is so treated as to obtain a clear solution containing 5 per cent. of lead oxide, to eliminate the sulphur and finally to yield sodic plumbite. Illuminating oils are subjected to rectification and refining in apparatus similar to those described above. Illuminating oil from Baku is known as "kerosene".

Rectified petroleum is a limpid and colourless liquid, without marked odour, having a density of 0.75 to 0.80. Its flashpoint, which should not be lower than a certain limit (varying in different countries; it is 21° in Germany, for instance), is determined by the Pensky or Abel apparatus. The addition to rectified mineral oil of ether or alcohol makes it explosive. Its fumes, when mixed in the proportion of 8 to 10 per cent, with air are also explosive.

1 Mineral oil is now not only a source of fuels and lubricants; it is, in addition, a chemical; for by using the aromatic mineral oils and some by-products, notably the gases from "cracking", extremely varied products are obtained.

Coke may be utilised as the carbon of an electrode: from methane, ethylene and other gases obtained by "cracking" may be obtained, by transformation, chemical products of higher value. The aromatic carbides of mineral oil make it possible for benzene to be separated, whence multiple derivatives can be obtained.

In the United States, the "cracking" industry is tending to undergo a change. It has produced anti-knock ethylene light fractions; and at present attention is concentrated on the utilisation of the fuels which it produces and on the manufacture of aromatic carbides. Among the processes, those of Holmes-Monley and Rittman enable a high percentage of benzene and toluene to be extracted.
Heavy Oils and Residues

The distillation of crude mineral oil, which is generally stopped at 300° C., leaves in the still a mixture of heavy oils, paraffins and tar, which constitutes crude vaseline. In Russia, this residue, called "mazout," is used directly as fuel for the boilers of locomotives and ships, for Diesel engines or for retorts for distilling mineral oil. Lubricating oils are extracted from the fraction of these crude products which, on distillation, passes over after the illuminating oils, crude products which, on distillation, constitutes crude vaseline. Lubricating oils are extracted from the fraction of these crude products which, on distillation, passes over after the illuminating oils, and is generally referred to as "residue".

The properties and proportions of these oils vary according to the nature of the hydrocarbons which enter into the composition of the crude mineral oil.

The residue distils at temperatures above 280-300° C. Its treatment comprises two principal phases: rectification-distillation, by which the oil is fractionated afresh into parts of different density and viscosity; and refining, by means of which the oil is freed from impurities and elements detrimental to lubrication.

Although the same order of operations is not always observed, the operations in the treatment of oils in most refineries includes: distillation; refining, which covers the removal of paraffin, chemical treatment, decanting, washing, treatment with absorbent earths, filtration and decoloration, washing and drying; the mixing and compounding of oils to comply with specifications laid down regarding viscosity, flash-point and freezing-point.

The manufacture of lubricating oils also yields some by-products, the greater number of which, depending on the nature of the crude mineral oils, are paraffin and petroleum asphalt, vaseline or oil of vaseline, petroleum jellies and coke.

The excess sulphuric acid, used for refining, is found in the vitriolic sediment. It is recovered or transformed into sulphate of iron or into superphosphate. If the asphalt is not extracted, these sediments are burnt under the stilts.

Treatment by acid has been given up, because the acid, which is difficult to eliminate, has such an injurious effect when the oils are used for lubricating machinery.

The residue of the distillation, diluted with ether and mineral oil and cooled, then leaves a deposit of vaseline, by means of a fresh distillation in vacuo, or by superheated steam, after the recovery of the solvent, heavy lubricating oils are obtained. The final residue is pitch.

These lubricating oils are liquids, varying in colour and viscosity. According to their physical properties, the oils produced are used for lubricating spindles, or gas engines, as light or heavy oils for machinery for cylinders, or for compressors. On mixing them with a soda or lime soap, greases of a firm consistency are obtained.

Gas-oil is a product of the distillation of tar obtained from mineral oil; it has a complex and variable chemical composition. Among the products which it contains are benzene, toluene, xylene and oils of creosote. Gas-oil occurs in the form of a light oil, with a density of 0.854; it gives off a peculiar smell, hardly to be defined, but persistent and disagreeable. It is used for the manufacture of grease and as a solvent, as an illuminant in lamps without glasses, or for making torches of a special type.

Residuary Waters

A great quantity of waste water escapes from a mineral oil refinery; it comes from (a) laboratories, store-rooms, and places for filling and despatching barrels; (b) the cooling of the condensers; (c) the tanks of crude mineral oil, from distillation by steam, from chemical treatments and from washing the barrels — all barrels after use are washed thoroughly before being used again.

The water from group (a) is simply run together and discharged into a river. That from group (b) contains only a small quantity of hydrocarbons; it is sufficient to pass it through a series of separators and then to filter it over coke.

The water from group (c), which is very impure, requires more careful treatment. Some of it being acid, and some alkaline, treatment is begun by mixing it in wooden barrels to cause partial neutralisation. The liquid so obtained has still an acid reaction; it is neutralised by milk of lime, and sulphate of lime is allowed to settle.

As a rule, all alkaline or acid water is strongly diluted with the other water coming from the factory, and the danger to the fauna in rivers is very small.

Toxic Effect

The toxicity of the products of mineral oil, and notably of benzene, is less marked than that of benzene (C₆H₆).
Heavy benzine is, in its turn, once and a half to twice as toxic as light benzine. These statements, however, have only a relative value, since the toxicity of the benzines, which are not well defined products, varies with their sources. But comparative studies on the toxicity of benzines from different sources have not yet been made.

The toxic effect of the volatile oils of petroleum acts chiefly on the nervous system. By means of experiments carried out on convicts at Bucarest, Felix found that, in most of the cases, 5 to 15 grm. inhaled for seven to twelve minutes caused dizziness, nausea, vomiting and sleepiness, as well as congestion of the conjunctivae and a sensation of burning in the chest. Anaesthesia and sleep were produced by inhaling 20 to 40 grm. for eight to twelve minutes, with individual variations from a marked susceptibility to a considerable resistance.

The inhalation of 45 mg. of light benzine vapour causes the death of such animals as dogs and cats at the end of two hours; but 60 mg. per litre of air — or exceptionally even 80 mg. — could, in some cases, be borne for twenty minutes without any inconvenience.

Haggard has experimented with gasoline fumes on dogs, and has found that the first disturbances occur with a concentration of 85 vol. per 10,000 vol. of air. When the concentration reaches 156, the animal is not able to stand; with 192 vol. per 10,000, muscular spasms are caused, and with 162, epileptiform convulsions occur. Another animal lost consciousness with a concentration of 238 vol. per 10,000 vol. of air, and death occurred after two minutes with 243 vol.

It has been possible to establish a definite gradation in the toxicity of the products of petroleum. Thus, petroleum ether is more toxic than benzine at 0.710 density, more toxic still at 0.740 density. It is not possible, however, to speak of an exact scale in the toxicity of these various substances, although it seems that the naphthene series are decidedly more toxic than the aliphatic series.

The toxicity of crude mineral oil is often due to the various impurities which it contains. This is particularly the case on the oil fields of Texas — the Panhandle Field, Big Lake Field, and McCamey Field — where among the harmful gases, sulphuretted hydrogen, which is present in the proportion of 0.20 to 10 per cent, in volume, plays a most important part. A mixture of one part of the gas from the McCamey Field with 50 parts of air is sufficient to cause loss of consciousness. In the mixtures of gas and air from the places where the men work, the concentration of sulphuretted hydrogen in the air varies between 0.01 and 0.07 per cent, and exceptionally, 0.10 per cent. Sulphuretted hydrogen accumulates especially in the confined spaces of the wells and tanks, which renders work in these places particularly dangerous. Its toxic effect is all the more formidable, and is exerted the more readily, owing to the fact that the olfactory sense of the workers is lost when they breathe this gas in high concentration. In many cases, the victim has not time to perceive his danger; and loss of consciousness occurs without premonitory symptoms. A fatal issue in such a case is quite frequent.

The refining of the residues of naphtha ("nigroses") after extraction from mineral oil, of gasoline and of the light oils, involves operations which are liable to produce toxic substances. Thus, the treatment of nitrate by sulphuric acid produces sulphur dioxide, the strength of which may vary from 0.54 to 1.29 mg. per litre of air, according to the operations. Experience shows that there is not, as a rule, acute poisoning, but that an injurious effect on the system is felt in the long run (Blinkoff).

It is important to note the report made by Lapkin and Jegorowa (1929), who found in Russian refineries of naphtha 0.20 to 16.80 mg. of fumes of light fractions per litre of air, large quantities of hydrocarbons amounting to 2 mg. and more per litre, as well as sulphuretted hydrogen. These quantities were naturally higher in very warm weather.

**Statistics**

Statistical data on the frequency and distribution of the various pathological conditions met with among oil workers are very limited. According to some Russian statistics of Berthelson dating as far back as 1895, it was found that among 8,485 workers there were 1,216 cases of dermatosis, 526 of burns, 1,475 of respiratory affections and 607 of physical exhaustion.

In another large Russian chemical works it was found, for 1896 and the following years, that per 100 workers there were 9.2 cases of diseases of the skin among the building workers and 11 cases among those who handled oils and colours.

An enquiry undertaken before the war in Germany by the Federal Bureau of Hygiene showed that out of 1,889 workers kept under medical observation for se-
In several years there were only 34 cases of acute cutaneous conditions and 9 of poisoning due to mineral oil. Chronic diseases or secondary complications were not observed. The cases of dermatitis occurred among persons employed on pumps and the distillation of mineral oil.

The reports of factory inspectors for the year 1919 show an increase for all European countries in cases of skin eruptions due to mineral oils. In Germany, 20 polishers out of 80 were affected by dermatitis; in Switzerland and the Netherlands, the affections have been ascribed to inferior oils used for drills, as well as substitutes for benzine and turpentine.

The incidence of dermatitis was especially great during the war years. The absence of cleanliness certainly contributed much to the development of these conditions. Thus, for example, Ullmann found that in a factory employing 1,000 workers the number of persons affected with acne fell from an average of 129 to 30 as soon as the taking of baths was made compulsory.

In Switzerland, the National Accident Insurance Fund notes under the heading of chronic poisonings by benzine from mineral oil: 1 case in 1922, 1 in 1923, 3 in 1924, 2 in 1925 (one of which was fatal), 1 in 1926, and 3 in 1927. The number of cases due to the skin due to the same injurious agent was 1 in 1922, 4 in 1923, 11 in 1924, 20 in 1925, 5 in 1926, and 12 in 1927.

In Ohio there occurred: from 1 July 1920 to 1 January 1927, 292 cases of dermatitis due to oil used on drills; 115 cases of poisoning by petroleum products made up of 68 cases due to light fractions, 29 from naphtha, and 16 from other derivatives of mineral oil; and 9 cases of sickness due to the effect of the volatile products of mineral oils.

In Azerbaijan, the number of cases of incapacity from sickness among mineral oil workers has been on an average equal to that observed among the remainder of the workers belonging to the Baku Insurance Bureau. Among the diseases, which, without, showing a particular frequency, seem to be characteristic of the occupation, are those due to frequent transport work, dermatoses due to chemical substances, diseases of the eyes and gastro-intestinal disorders. As regards the number of cases of sickness, there seems to have been a general increase compared with the situation before the war, whilst the gravity of the various cases seems to have diminished (Sevald).

In Argentina in 1931, studied the pathology of workers employed in the distillation of mineral oil. He groups the symptoms observed into two categories: those due to volatile hydrocarbons and those due to sulphur compounds. The ill-effects due to hydrocarbons are characterised by nervous disorders, irritation of the mucous membranes, nausea, vomiting, headaches, strokes; in the acute cases, by the form known under the name of petroleum intoxication; in the chronic forms, by anaemia, with eosinophilia and disorders of the digestion and of the liver.

**PATHOLOGY**

Occupational diseases in the mineral oil industry are due, on the one hand, to the inhalation of fumes from mineral oils and volatile oils, and, on the other hand, to the irritating effect exercised on the skin by petroleum, the light fractions or lubricating oils. Some general symptoms of poisoning have also been observed from the absorption through the skin of substances contained in the mineral oils.

**Mineral Oils**

The data relating to ill-effects caused by mineral oils are fairly numerous, but as a rule they are comparatively out of date. In Russia, while Burenin in 1888 denied the occurrence of ill-effects on the occasion of an enquiry he undertook, they had actually been noted since the beginning of the 19th century. Chiefly, Weinberger, in 1893, by Jesener and Bieleczky in 1896, by Korschewsky in 1887, by Lewin in 1888, who made a journey to the United States to supplement his Russian experience, by Sharp in 1888, by Istomin in 1896, and by Nikolajewsky in 1907.

In France, Chevallier in 1864 studied skin affections caused by mineral oil; Poincaré in 1883 reported some injurious effects among workmen breathing air charged with mineral oil vapour; in 1886 an inquiry was made by Broca and Remy to study the injurious effect of mineral oils on the skin. Dankworth in 1888 described cases of dermatitis under the name of petroleum intoxication; in France, Derville and Gueronprez in 1891 reported cases of papilloma among refiners with erythema, itching, eczemas and pustules. Sinatowsky observed similar cases in 1893. These observations have been confirmed in the different mineral oil centres where imported mineral oil is refined. In France, Derville and Gueronprez in 1891 reported cases of papilloma among refiners, which Brémond in 1895 considered as very rare if measures of personal cleanliness are adopted in the works; out of 300 refiners whom he was able to examine there was only one case of papilloma.

The ill-effects caused by inhaling the vapour of crude mineral oil, observed particularly in distilleries and refineries, varies according to the origin, e.g. American or Russian, and the purity of the oil. The sudden inhalation of mineral oil fumes, without sufficient
oxygen; leads to symptoms of very acute poisoning, with loss of consciousness and a fatal result if the victims are not at once carried into the open air. The most serious forms of poisoning have been observed among workmen employed in tanks or on tank wagons which have contained mineral oil, and have not been sufficiently ventilated. Then again repair operations (heating, soldering) may lead to the liberation of poisonous fumes from the residues of distillation sometimes found between the iron covering and the lead lining of the apparatus under repair. The flame of the blowpipe has, in some cases, caused an explosion in the apparatus.

The inhalation of an average quantity of vapour during a more or less prolonged period in an atmosphere insufficiently supplied with oxygen leads to varied conditions of acute poisoning: sometimes, a state of excitement resembling that of drunkenness, with confused ideas on the part of the workman who may refuse to leave the tank or place of danger he is in (Lewin); and sometimes a state of fatigue, somnolence, feeling of intracranial pressure, tinnitus and vertigo. In the most serious cases, lethargy lasting several days has been observed, with loss of consciousness, retrograde amnesia and excitement, which may go as far as to simulate an attack of real acute mania; and sometimes delirium and hallucinations.

In the body itself, tremors, tendon jerks and clonic convulsions have been described; neuritic disturbances, with paraesthesia and disorders of speech; of deglutition and respiration; sometimes a fall of temperature with diminution in the respiratory and associated cardiac frequency and cyanosis of the peripheral parts with a sensation of cold.

The inhalation of a small quantity of the gas causes states of slight inebriety or simply a sensation of vertigo and intracranial pressure, which disappears as soon as the victim is carried into the open air (Koelsch).

Chronic poisoning has also been described, characterised by anaemia, vertigo, rhinitis, mydriasis and general asthenia.

Mineral oil and its derivatives in addition cause respiratory affections: acute tracheobronchitis with violent cough and attacks of suffocation, notably in the case of persons who have inhaled fumes of crude mineral oil. This inhalation was followed in one case by an inflammation and a typical pneumonia; and in another case by cough accompanied by bloodstained sputum and a pleuritic effusion. Besides these acute forms, numerous cases have been observed, on the oil-fields of Baku, of chronic bronchitis, nervous disorders and anaemia attributed to the prolonged action of the products of mineral oil (Korschenewsky in 1887 and Petkevitch in 1898). Some fatal cases have been registered where the men worked in badly ventilated places. J. W. Hall reports cancer of the lungs among mineral oil refiners from inhalation.

As regards the digestive organs, anorexia, digestive disorders with regurgitation from the stomach and vomiting, intestinal disorders and diarrhoea have been observed.

Derivatives of indol (indican) have been found in the urine.

As regards the eyes, irritation of the conjunctiva, nystagmus, disorders of the pupils with mydriasis, and paralysis of the eye muscles have been observed (Ullmann). The conjunctival irritation seems to be due to the combined effect of emanations from mineral oil and sulphuretted hydrogen; it may reach serious forms with photophobia and temporary blindness. Often very painful lesions occur, which cause incapacity for work for several days. Many of the eye troubles are due to negligence or lack of knowledge concerning the danger, and to insufficient care taken about cleanliness.

Skin affections are quite common among workers in mineral oil, especially when the hygienic conditions are not all that could be desired; they are due, for the most part, to the injurious effect of the products of distillation. The chief impurities in question are those which sulphuric acid is capable of dissolving and eliminating. Purified mineral oil causes only slight dermatitis, with folliculitis and acne, accompanied by very great itching; whilst crude mineral oil causes chronic lesions with a tendency to hyperkeratosis, the production of warts and, often, epitheliomatous new growths.

Prosser White classifies as follows the injuries caused to the skin by mineral oil and its distillation products:

(a) Petroleum-benzine, petrol or gasoline naphtha (boiling point 150° C. and under): superficial dermatitis: dry, scaly skin, eczema with fine vesicles, pimples and pustules.

(b) Lamp or lighting oils (boiling point 150-300° C.): popular or pustulous eczema, miliaric folliculitis with or without perifolliculitis (acne) and abscess.
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(c) residuum (boiling point above 300° C.) erythema, senile keratosis, punctiform folliculitis, warts, ulcers, carcinoma.

These cases of dermatitis may be complicated by the occurrence of secondary infections. A special form known as "refiner's itch" has been described.

Ullmann distinguishes clinically the following forms of skin affections:

1. Diffuse dermatoses, slight or severe, acute or chronic, situated usually on the upper limbs, more rarely on the face and lower limbs.

2. Eczema caused by crude mineral oil, with the formation of vesicles and pustules, generally situated on the hands, forearms and thighs.

3. Comedones and other follicular inflammations, situated chiefly on the face, on the dorsal region of the hands and the front of the thorax. The scalp and genital organs are more rarely affected. These affections cause intense itching, from which comes the name "refiner's itch".

4. Diffuse or circumscribed hyperkeratosis, with or without pigmentation and the formation of warts or other papillomatous excrescences, which are attributed to the action of certain elements in the heavy oils and crude vaseline.

5. Chronic ulcerations of the skin with malignant degeneration and a tendency to metastasis.

6. Pigmentation of the skin on places where there are eczematous changes or hyperkeratosis.

Gas-Oil

Gas-oil, when used for lighting, gives off smoke with a disagreeable odour, and gives such an insufficient and irregular light that it has been considered as liable to cause eye-strain. Workmen who use it complain of headache, vertigo, irritation of the respiratory passages with cough and expectoration, the nasal mucous membranes being charged with soot, loss of appetite, nausea, vomiting, gastralgia and constipation. After some time, wasting and fatigue make their appearance.

As a solvent or defatting agent gas-oil causes, in addition to symptoms of a general kind, local affections: itching, sharp sensation of burning of the skin, conjunctivitis, tinglings and sneezing.

On the skin, there may be found a persistent blackish coloration, with a tenacious incrustation — resistant to washing — about the follicles; small cracks and fissures appear, accompanied frequently by oedema, pruriginous erythema, acne, furunculosis and eczema, which may be dry or pustular. There have also been noted papules on the forearms, small and multiple warts; and also an extreme fragility of the nails (Langelez).

Some recent observations on cases of dermatitis from gas-oil among locomotive cleaners have shown that such cases are not caused by gas-oil when it is mixed with recuperated oil.

Petrol

Petroleum naphtha or petrol, which is increasingly used either as a fuel, or as a solvent, or for removing stains, causes not only more or less serious cases of acute poisoning, depending on the conditions in which the victim works, but also chronic affections. These latter are, according to experts, more common than is usually believed; for, unfortunately, the symptoms are not always sufficiently definite as being characteristic of this form of poisoning.

It is evident that the use of petrol as fuel is all the more dangerous when the place where the engine works is cramped and badly ventilated, e.g. in submarines and places for testing engines. Years ago Judell (1876), Lewin (1879) and Schroff (1881) showed that this substance acted on the blood by setting free the haemoglobin. Numerous authors have since then drawn attention to the danger from petrol (see article "Garages"). It is, perhaps, worth noting the importance of nerve disorders which have been described in some cases. Thus, Peters in 1900 observed a case of retrobulbar neuritis (non-occupational), and Soupault and François in 1901 reported some cases of polyneuritis in women who cleaned gloves with a mixture of benzene and ether from mineral oil. Gowers in 1908 reported a case of pseudomyas-thenia from the fumes of petrol in a person who tested engines running in a small and badly ventilated room. Hayhurst in 1913 reported 33 cases of injuries due to petrol among painters, enamellers, dry cleaners and varnishers in Ohio. Potts in 1914 described a case of paralysis with loss of consciousness in a workman who filled the tanks of motor-cars; and Dancer in 1915 observed a case of poisoning which was followed by a serious lesion of the spinal cord. Haden in 1919 reported a case of poisoning in a man who cleaned lithographic rollers daily.
using 9 litres of petrol; the patient suffered from vomiting, vertigo, a confused state, cyanosis and a slight leucopenia. Hamilton has studied several cases of poisoning among women who worked on rubber and among painters. In 1922, O. Spencer studied the effects of fumes of petrol or gasoline on a group of 42 workmen who showed slight chronic poisoning; among 22 of these workmen he found headache 13 times, of which 8 only occurred in the afternoon, somnolence 11 times, of which 5 only occurred in the afternoon, intoxication 9 times, orbital pains 8 times, irritation of the conjunctivae 12 times, excessive lachrymation 11 times, fatigue 8 times, and frequency of micturition 6 times.

In 1928, Merle described in France a case of serious poisoning during the repair of a petrol tank, with delirium, excitement, loss of consciousness and coma; and Escartefigue described 3 acute cases due to gaseous products from the combustion of petrol on a small boat on which a petrol motor was used to generate electricity. Duvoir has shown the general effect of mineral oil and petrol, with respiratory disorders, serous apoplexy, neuritis and conjunctivitis, as well as its local action on the skin, setting up superficial vesication.

Among women handling petrol as a solvent, authorities report frequent vomiting and attacks of euphoria or exuberance, which quickly disappears in the open air. In other cases vomiting is absent and those poisoned become stupified, and sometimes fall into a faint; these latter are women incapable of developing tolerance for the poison.

Cases of poisoning have been reported among workmen who have charge of small petrol motors in tunnels, by Johnson in 1913, and by Albaugh in 1916. It is, however, only in cases where carbon monoxide has not been detected, either in the air or in the blood, that poisoning can be attributed with certainty to petrol.

**Lubricating Oils**

These oils, which are very largely used in all industries, are generally classified in three groups: oils derived from mineral oils; oils obtained by distillation of certain shales; and tar oils from coal. In practice, it often happens that the mixtures of these different products, sometimes even with the addition of oils of a different nature (animal or vegetable oils).

Workmen who handle petroleum oils often have upon the hands and arms; pricks from shavings or from rough steel edges, invisible fraying, or burns caused by the projection of boiling oil in very fine spray, or indurations from the lubricant or from rags used for wiping the hands, arms or even the face may occur in consequence, thus resembling cases of dermatitis and oil acne, frequently met with in this class of workers.

As a matter of fact, mixed forms are more frequently met with, especially in the case of products distilling at the higher temperatures. Prosser White considers that the intensity of the dermatitis in these cases depends on still other factors, such as the strength of the iritant, and the kind of resistance and reaction offered by the skin.

Blaschko in 1911 described skin affections due to oil among printers who clean or lubricate large machines; this same author, as well as Alfred and Fisch in 1920, described lesions which he observed under four groups: indolent folliculitis, which is often prurigenous; follicular keratoses, melanodermia of the exposed parts of the skin; and warts. Davis in 1920 described lesions which he found in workmen employed on presses where paraffin oil is obtained. W. J. McConnell in 1922 published the investigations he had begun in 1919 on the action of oils for drills. Among 2,000 workmen examined, he found a characteristic dermatitis 557 times (27 per cent.). Collis has reported 14 cases of dermatitis caused by a mixture of turpentine and an alkaline emulsion of petroleum; he has also observed some cutaneous affections caused by shale oil among mechanics. In a sewing-machine factory at Potsdam, 120 out of 1,000 workmen were affected by dermatitis caused by lubricating oils containing hydrocarbons. The workmen of a spring factory at Frankfurt-on-the-Oder suffered from affections caused by an oil which contained creosote; and the workmen of a string factory suffered from skin affections due to a mixture of mazout and tallow (6 per cent.) with which the manufactured article was smeared. Oil from lignite was regarded as the cause of dermatitis found among the workmen in a pottery factory by Saxe in 1920; and lubricating oil to which phenol had been added caused affections among 20 per cent. of workmen in a factory. Among workmen handling tar oils (Schmieröle) a special skin condition has been reported, which was particularly noticeable during the war. It consisted of a moist dermatitis
rarely serious, characterised by comedones, pustules and sometimes by eczema, situated on the hands, forearms, the neck, and, as a result of contagion by dirty hands, on other parts of the body. A case of rhagade on the lips has even been observed. Examination of the oil revealed the presence of naphthalene in a proportion of 1 to $\frac{1}{3}$ per cent. (Eisner, 1924).

An oil used for lubricating the valves of motors caused several cases of dermatitis. It was purplish-blue, with a smell of oil of gaultheria, and is known as penetrating oil; it is used for cleaning and as an anti-corrosive. It usually contains mineral oil, benzene, petrol and oil of paraffin, alone or in different combinations. It has also become common to contain heavy oils, phenols, cresols, colouring matters and even deodorisers. When this oil is used on a motor which is running, aldehydes and acrolein are given off.

The action of various ingredients and impurities which lubricating oils contain, such as hydrocarbons, sulphuric acid and alkaline sulphophenolates, has led Blum to think that the skin lesions ought to be attributed to foreign bodies which contaminate the oils, and not to the oils themselves.

Oil Acne

For almost twenty years skin affections, known under the names of "furunculosis" or "oil acne", have been recognised as due to infectious agents.

Oil acne, which was first described by Purdon, of Belfast, in 1887, appears most commonly on the parts exposed during work: hands, forearms and face. Sometimes it occurs upon the abdomen, the thighs and the legs, in consequence of the clothes of the workman being soaked with oil. Oil acne may be accompanied by a sensation of heat and itching; the patient scratches himself; the lesion extends; and the dermatitis may become generalised on the hands and the forearms, generally bilaterally. When the lesion becomes infected secondarily it is accompanied by the complications which are common to all occupational dermatoses. In that case it lasts several months.

In 1911 an epidemic of furunculosis was observed in a factory at Cleveland (Ohio) among half the workmen employed on lathes requiring lubrication with lard oil, the use of which is rather exceptional for the lubrication of machines. The consumption of oil was about 4,500 litres per month. By centrifuging, in order to separate off the solid particles, and sterilisation of the product, the infectious agents were eliminated. In 1917 Shie reported an outbreak of furunculosis in another factory which employed about 2,000 persons, where 35 per cent. of the turners were affected.

Purification of the oil, infected by pyrogenic organisms, was carried out by chemical disinfection, using cresols 0.5 per cent. In 1918, Albag and Hayhurst found that. in a factory at Columbus where metal articles were made, the oil used for the drills carried Staphylococcus aureus. These authors consider that chemical disinfection may increase the irritating effect of the oil, and they have advised sterilisation by heat. On the other hand, Page and Bushnell have reported that some bacteria retain their vitality in oil for long periods, such as eight months.

In some cases the particular use determines the injurious action of lubricants. Thus, an oil which is not irritating even if rancid, e.g. lard oil, becomes so as soon as it has been used on machinery.

The quantity of lubricating oils employed every day in industries is considerable; in the United States some automobile works use about 6,000 litres a day. It is obvious, that, in these conditions, it is essential to study the best method for recovering a part, at least, of this quantity. With this object in view, recourse is had to the centrifuge and to heat; to sterilisation followed by a fresh centrifuging; to sedimentation; or, again, to these methods combined. In this way the metallic particles are removed and the infectious germs which the used oils may carry are destroyed. Neutralisation of lubricating oils by washing with alkaline solutions and then filtering is recommended, as far as this is possible. On the other hand, mixing oils and hydrocarbons must be avoided, and the number of days the oils are used must be reduced to a minimum.

Chemical analysis has shown that the degree of alkalinity of some products was not excessive; on the other hand, acidity varying between 0.08 and 0.34 per cent. has been found. Thus it may often be that an exaggerated acidity, over a long period, may cause direct affections, or at any rate impair the resistance of the epidermis to bacterial infections. The presence of such light or volatile hydrocarbons as oil of illuminating, may cause an irritant action similar to that produced by acidity; the proportions are, however, very small, and can only
play a part of secondary importance. Bacteriological analysis has shown that, in addition to some oils which are sterile, there are others which contain microbes (almost exclusively staphylococci). The presumption is thus also be taken for granted in the so-called "clean" rags used. Now, all these factors are capable of causing oil acne, as well as other forms of dermatitis.

In 1916, in French turning shops, Etienne Martin reported numerous cases of oil acne. The same year, Borne and Kohn-Abrest laid before the Society of State Medicine their researches on this subject. Whilst under normal conditions of work this affection was formerly very rare or even unknown, the use during the war of some machine tools which required considerable quantities of oil, from 50 to 100 times more than usual, brought some machines into permanent contact with veritable showers of oil. This thread, laid before the war, was utilised, up to the point of extinction of any lubricating power, soapy water, petroleum containing vegetable oils derived from peanuts and colza, ammonia, acids, and an oil of American origin called "compound". The use for a whole week of the same lubricant pumped round and round according to the requirements of the tasks, kept the microbes in the atmosphere, some of them containing vegetable oils, but not vegetable or animal oils, this author has found suppurative folliculitis; in the midst of the hair follicles and of the blocked sebaceous glands pointed projections appear which are at first red, but undergo suppuration later. The charge from the suppuration of the gland forms a crust on drying. This is of the opinion that the condition is encouraged by the abrasions due to fine particles of iron contained in the used oils; the base of the hairs and the ducts of the sebaceous glands are in these patients filled by small, solid, black masses, formed of fine particles of iron. According to Thierry, oil acne occurs as a round pustule, 2 to 6 or 8 mm. in diameter, usually slightly raised, with tough walls containing thick pus. This pus is composed by a layer of a narrow, red, slightly infiltrated, inflammatory zone, which tends to open spontaneously. Once open, the orifice remains in that state for one or two weeks and the inflammatory zone surrounding the pustule slowly disappears. In addition to this type of pustule, there are other types without infiltration at the base, which develop more rapidly and form a large quantity of pus. These pustules multiply by auto-inoculation and show several characteristics of streptococcal erythema. In some persons, numerous comedones and acne spots develop, usually around a hair.

Blum, when studying oil acne, notes that at the beginning this lesion is accompanied by a slight itching. Little by little, a number of black points develop, which are not removed by washing; then, by blocking of the follicles with dust mixed with oil, violet red or brown, or sometimes pink pustules are formed, generally flat, more rarely conical; their size varies from that of the head of a pin to that of a small pea. Some pustules have a raised centre containing a drop of yellowish pus, with a black spot in the middle; that is the papule-pustule. In other cases the pustule has a vesicular aspect, constituting a vesicular pustule. The lesions, however, vary with the kind and quality of the oil, the duration of exposure, the microbial infection, the dirt, dust, and metal in suspension in the oil.

It has been found among ships' firemen that the increasing use of mazout has led to a greater development of oil acne. In 1921 Noell, of Montpellier, investigated occupational dermatitis caused by mazout. Huguenin in 1926 described a cancer of the skin which developed on a burn from mazout. Further, the investigations undertaken under the auspices of the Manchester Cancer Committee into the part played by lubricating oils in the production of cancer have led to the admission of the existence of a carcinogenic substance in some oils. This substance, used in a solution of 5 per cent., has been found more active than bituminous oil (shale oil), which is considered as the most dangerous. (See articles "Shale Oil Industry" and "Tumours of Occupational Origin (Occupational Cancer)."

**HYGIENE**

Mineral oil workers should be supplied with means to enable them to practise good personal hygiene. All contact with injurious substances must be avoided by providing the workers with impregnated head coverings with broad brims and coverings for the neck, overalls, mackintosh aprons, gloves and high boots. The condition of the skin of the workers must be
regularly examined in order to detect slight irritations which may end in more serious skin conditions. Cleaning the hands with benzine, which is quite common in the refineries and distilleries of mineral oil, should be prohibited, for, though the skin is thus thoroughly cleansed, in the long run this method causes an injurious effect by removing the grease from the epidermis, and rendering it rough. On the contrary, thorough washing of the skin with soft soap must be insisted on, followed by greasing with lanoline or carbolised glycerine.

Men working in wells, tanks or other closed spaces where the amount of toxic gases may be dangerous, should be provided with respiratory apparatus and life lines, and with special goggles against the irritating effect of the gases. One or more first-aid stations should be provided, equipped with necessary appliances and drugs, and especially with oxygen apparatus.

Tanks and workplaces must be thoroughly ventilated, and they must be warmed with steam before they are opened, and before the entrance of workmen, either for cleaning or for repairs. All gases from the plant should be mechanically absorbed and rendered inoffensive. Protection must be provided against the high temperatures of the distilling apparatus.

Gases may come off from wells, even at 5° C.; hence danger from explosion and fire is always present. Careful supervision must be exercised over the liberation of these gases, and particular attention must be given to the pipes carrying the liquids to the tanks and retorts. Explosive mixtures with air must be avoided; for this purpose every receptacle must be connected to a system of carbon dioxide under slight pressure (about half an atmosphere) in such a way that the oxygen of the air cannot come in contact with the inflammable liquid.

There must be a special system of artificial lighting, and safety lamps should be used. Smoking should not be allowed in the department used for extraction, distillation or refining mineral oil. There should be a system of hydrants with hose and also a fire brigade.

Before discharging the waste products, they should be collected in cement tanks sunk into the ground, regard being had to the grave danger from explosion, and the ease with which combustion of a mixture of waste with benzine hot liquid tar takes place. The discharge of waste water containing hydrocarbons into sewers must be prohibited, as experience has shown that men working in the sewers and using naked lights may be injured by explosions. The unhealthiness of work in gasoline factories is due to the nature of the raw materials used, the process of extraction from natural gas, and the kind of product obtained.

The factory should be isolated as much as possible so as to minimise danger from fire or explosion. The various sections of the works should be spaced out. The height of the tanks should be reduced. The construction of the retorts should be supervised. There must be automatic regulation of pressure; adequate ventilation; and meticulous control of the strength of all the parts of the apparatus. The workshops where the most dangerous operations are carried on should be isolated as far as possible. Any possibility of ignition, say from static electricity, must be guarded against; smoking must be absolutely forbidden; use of naked lights must be forbidden. and electric lamps should have a double cover. Volatilisation of gasoline in the tanks must be prevented as far as possible; with this object a low pressure should be used.

Experience shows that 18 per cent. of industrial accidents are due to bad lighting, which, in addition, has the effect of reducing the workers' output. It must be remembered that chlorine gas, when mixed with certain hydrocarbon emanating from gasoline, liberates hydrogen, forming an explosive mixture, which explodes with all the more violence since sunlight may set the reaction going.

Stationary extinguishers should be numerous; provision for these should be made even during the construction of the factory. Inspection of temperatures and, pressures should be periodical and careful.

As regards work with petrol it is recommended that nervous women and alcoholics who do not acquire tolerance should be excluded. Further, workers who have had intermittent fevers, or those who are insufficiently nourished, bear the effect of these fumes badly. As a general rule these fumes are not so easily tolerated on Mondays, or in thundery weather, or during sudden changes of temperature.

The prophylactic measures to be observed for workers handling lubricating oils were summarised by A. C. Hall in 1923 as follows: non-irritating oils, if possible free from germs, should be used; there should be periodic bacteriological examination of oils; the oils should be filtered and sterilised. Workers should be selected; personal cleanliness should be insisted upon; spitting
into the oil should be prohibited; the use of common towels must be forbidden; separate towels should be provided for each worker; soft soap should be used; washing the hands with alkaline water must be forbidden; workers who have infectious diseases of the skin must be dismissed; even the simplest lesions of the skin must be treated without delay. Propaganda is needed for the instruction of workers (leaflets, and advice during medical examinations).

LEGISLATION

Women are as a rule excluded from the refining and distillation of mineral oil and of hydrocarbons. Young persons under sixteen years are excluded in Belgium and in France both from warehouses and factories where work on a large scale is carried on in mineral oils, shale oils and petroleums; children under fifteen years and women under twenty-one years are excluded in Italy.

In Germany the measures laid down for the protection of workers employed in the extraction and refining of mineral oil (25 January 1905) have been reproduced in the Ordinances of the States (Prussia, 3 February 1905, etc.).

Other special regulations have been laid down in Canada (Alberta: Regulation of 15 May 1928 on the boring of wells); in Mexico (Regulation of 17 October 1927 on mineral oil work: sections 335-336: Health and Safety); in Rumania (Regulation No. 716 of 6 April 1926 on the inspection of operations with mineral oil and its gases); in the U.S.S.R. (Order No. 312-412 of 3 December 1955 on the work of men employed in cleaning boats used for carrying naphtha).

Injuries caused by mineral oil and its derivatives, during refining and during its industrial treatment are subject to compulsory notification in the Netherlands; those caused by benzene from mineral oil in Bavaria and in the U.S.S.R.; those caused by mineral oils, used for lubricating, etc., in France and the Netherlands. The same injuries are compensated in Finland, if due to benzene from mineral oil, in Great Britain, if due to mineral oil. In Western Australia, in Queensland, in Minnesota, and in the State of New York, cancer so caused is subject to notification in the State of Ohio, cancer and superficial ulceration of the cornea; injuries caused by hydrocarbons are subject to notification in Argentina, Brazil, Bolivia, Minnesota, New York, and Ohio; in Pennsylvania and Switzerland those due to the volatile products of mineral oil.

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Pharmaceutical Chemists, Druggists and Herb Vendors


Even the ancient writers — Dioscorides, Forestus, Leonardo da Capua, Antoine de Haen, Ramazzini, etc. — were already aware that the occupation of pharmaceutical chemist and druggist involved numerous risks to health in consequence of manipulation of diverse toxic substances of mineral or vegetable origin (lead, preparation of plasters, syrups, etc.).

Amongst modern authors Koelsch has devoted a study to injuries to which pharmaceutical chemists and druggists are exposed in grinding, crushing, kneading, pulverising, distillation, evaporation, etc., i.e. the preparation or simple manipulation of numerous organic and inorganic chemical products which it would take too long to enumerate. Koelsch has noted, as symptoms of poisoning by mercury, nervous irritability with excessive perspiration and anaemia, especially amongst women workers, and marked dental deterioration. In the case of thirteen workers he noted irritation around the lips and nostrils, small cutaneous ulcerations on the fingers and alteration of the nails (friable nails and inflammation) which he ascribed to the corrosive action of the sublimate.

Alkaloids cause an irritation of the skin and the mucous membranes or, idiosyncratic, reactions which are often very serious amongst persons with special predisposition. Manipulation of alkaloids (strychnine, brucine, atropine, apopatrine: Héxheimer, 1912; morphine: Lewin, 1908; codeine, cocaine, quinine, opium, etc.) may give rise to characteristic troubles, which have also been noted with hydrastine, vombine, quinine and various products of ergot of rye (see the articles “Cocaine”, “Opium”, “Quinine”, etc.).

Sorting, mixing and grinding of various vegetable substances involve liberation of dusts, the harmful action of which varies in accordance with the product in question. Dust from birch leaves causes sneezing, that from gallnuts dryness of the mucous membrane and giddiness, that from hops somnolence; ipecac. and quillaja powder may give rise to facial oedema accompanied by conjunctivitis, opacity of the cornea, cold, sialorrhoea, spasm of the oesophagus, bronchitis and attacks of an
asthmatic type (Varekamp), nausea, vomiting, shivering, etc. Amongst the most recent cases noteworthy are some mentioned by Widal, Abrami and Joltrain, a pharmaceutical chemist who suffered from asthma after inhaling the odour of ipecac, and a laboratory assistant who suffered from eczematous dermatitis of the face after handling emetine powder. The prolonged action of mustard fumes causes an injury of the cornea analogous to that caused by nitro-naphthaline fumes. According to Pick (1901) the workers affected suffered from slight but total opacity of the cornea more perceptible at the centre where it appeared as a very broad horizontal band. The opacity was due to small superficial transparent vesicles very close to each other on the open side of the cornea corresponding to the palpebral opening, with consequent diminution of sight, sensibility of the cornea and myosis. The vesicles do not open. Healing commences at the periphery, progresses towards the centre and is complete in the course of some weeks. The case of Neustatter (1901) was that of a pharmaceutical chemist attacked by fumes from mustard oil, which caused marked conjunctival hyperaemia, lachrymation, photophobia, with corneal opacity from the first few days onwards; it had not cleared up. The injury is due to the essential oil of mustard which is formed during grinding as soon as the mustard comes in contact with hot water. Eating grains of mustard has caused painless necrosis of the teeth.

Irritations of conjunctival irritation have been recorded in consequence of the handling of euphorbium, vanilla and podophyllum powder (see article "Podophelline").

Pulsatille powder has caused attacks of colic, vomiting and ocular troubles (conjunctivitis, anaesthesia of the cornea and hyperaemia of the retina, etc.). Sabadilla powder causes violent sneezing, rhinorrhagia, headaches, pharyngal catarrh (action of veratrine, an alkaloid of sabadilla). Croton tiglium, handled without precautions, causes, besides irritation of the mucous membranes, oppression of the chest, gastralgia and vertigo accompanied at times by collapse, dyspnoea and mydriasis. In the course of drying cakes made of dust of the castor-oil plant (1/250,000) a chemist is reported to have suffered from irritation of the eyes with lachrymation, corzya and asthma (Breton, 1923). The powder of Veratrum album causes sneezing; epistaxis, laryngo-pharyngal catarrh and headache. Workers engaged on a preparation of colocynth have suffered from symptoms of poisoning (see article "Colocynthia"). Intestinal troubles may be caused by phenolphthalein and alizarine red, the latter causing also red coloration of the urine and excreta. Pyrethrum powder may induce chronic rhinitis, asthma, conjunctivitis and certain forms of dermatitis on the face and hands.

A case of itch in a druggist due to an acarus has been described by Ciarrocchi (1930).

Prosser White (1920) has assembled under the designation "drysalters' itch" all the forms of dermatitis noted as occurring amongst this category of workers. Cutaneous troubles have been reported as following from the manipulation of borax (Hazen, 1914), various preparations of sugar, hydrochlorate of phenylhydrazine (localised or radiating erythemas on the face, scrotum or thighs, etc.; Hall, 1899; Galloway, quoted by Alibutt and Roleston, 1911), formic aldehyde (dermatitis and lesions of the nails: 5 cases noted by Galewsky, 1905, amongst chemists and laboratory workers, six to nine months after employment in handling the product; one case of generalised urticaria: Glover, 1901). Forms of dermatitis have been caused by the preparation of plasters or tinctures of cantharides (Oppenheim, 1914), by the manipulation of peroxide of hydrogen and iodine (Sabouraud, 1915). Apart from these cases, due to products which they handle, pharmaceutical chemists and druggists are further exposed to the risk connected with tools and apparatus utilised by them; inhalation of combustion gases (gas jets, etc.), cuts and wounds from glass, explosions (solvents: alcohols, ethers, etc.), burns, etc. (See also article "Medical and Allied Professions (Occupational Pathology of").

Reference has also been made to forms of cramp and paresis amongst workers engaged in preparing by hand pills and tablets, etc. The constant spread of mechanical apparatus is eliminating this risk.

Two cases of anthrax have been reported among druggists engaged in cutting up leaves of Dalatura stramonium from Hungary.

**Hygiene**

Hygienic measures comprise protection of workers engaged in operations liable to give off harmful gases, fumes and dusts; fitting of effective ventilation devices on apparatus without hoods; execution of operations as far as possible in closed vessels; provision
of masks or respiratory apparatus for workers and of oxygen in case of necessity; personal hygiene: washing accomodation, douche baths, working clothes, etc. Instruction of workers in the risks attending their work.

**LEGISLATION**

Women and young persons under eighteen years of age in France, and of boys under sixteen and women under twenty-one in Spain are excluded from mustard plater manufacture with hydrocarbons (workshops in which solvents are handled).

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**Phenols**


The phenols are those of the substitutive derivatives in the benzene series that have OH groups in the place of one or more atoms of H of the benzene nucleus. Some phenols are partly soluble in water; all are soluble in alcohol and ether; they distil unaltered. When distilled with zinc powder, the phenols give the corresponding aromatic hydrocarbons. Speaking generally, they have a reducing action. They react with the nitro compounds and other substances to give dye-stuffs. With formic aldehyde they yield characteristic resinous products of condensation, e.g. bakelite (see that article).

Phenols are extracted from tar obtained by the dry distillation of coal or wood. They have a characteristic odour (phenol, thymol).

Anisol (C₆H₅O.C.H₃) is obtained by heating the alkaline phenates with alkyllic iodides.

Among the halogen phenols may be mentioned tetra- and penta-chloroanisol (C₆Cl₅O.C.H₃). (For cresols, see that article.)

Anethol is another homologue of the phenols; it is solid and colourless, with a very agreeable odour of aniseed.

The diphenols, or bivalent phenols, contain two hydroxyls joined to the C of the benzene nucleus. They are prepared by processes similar to those used for the monovalents, to which they are closely analogous. There should also be mentioned pyrocatechin, resorcin and hydroquinone. (See also the articles "Dinitrophenol", "Aminophenols" and "Pieric Acid").

Pyrogallol, or pyrogallic acid, is one of the trivalent phenols. Among the polyvalent phenols it will suffice to mention hexoxybenzene.

The quinones remain to be mentioned; they may be considered as derivatives of the phenols by the elimination of hydroxyl, with consequent displacement, and partial elimination of the double links in the benzene nucleus. They are generally yellow in colour, with a piquant odour. They are oxidisers; and can be carried by steam, undergoing partial decomposi- tion during this volatilisation.

**TECHNICAL DATA**

Phenol or carbolic acid is extracted from tar oils treated repeatedly by small portions of caustic soda solution, while a current of air keeps it agitated. First, phenol is extracted, then the cresols, and finally, with a more concentrated solution of caustic soda, a large part of the neutral tar oils can be dissolved. The alkaline solution of phenol, after being decanted, may be purified by means of a current of steam which eliminates the naphtha-line; the phenol is then separated by means of carbon dioxide or sulfuric acid. After several washings with water, crude phenol, or "grey phenic acid", is obtained; it is of variable composition, and appears as a reddish or brown liquid, with a strong and repellent odour, containing 50 to 95 per cent. of phenol, homologues (cresols) and variable quantities of hydrocarbons.

The crude phenol is purified by several fractional distillations between 175° and 185° C., or until it crystallises and does not become red on exposure to the air. By suitable operations a chemically pure phenol can be obtained.

Synthetic phenol was obtained during the war, starting from very pure benzol. The necessary quantity of
concentrated sulphuric acid is first poured into an iron vat, heated indirectly by steam; it is stirred without heating; the temperature is then raised to 115° C. in order to obtain benzene-monosulphuric acid; the acid mass is then poured into a hot, almost saturated, solution of sulphate of soda to remove the excess of sulphuric acid, and to separate, by cooling, a crystalline mass of benzene sulphonate of soda. The crystals are centrifuged and poured into melted caustic soda, which is then heated. The melted mass of phenate of soda and sulphite of soda is poured into a little water; the sulphite is thus separated from the solution of phenate of soda; it is filtered; by means of dilute sulphuric acid, the phenolic acid is liberated as it floats on the solution of bisulphate of soda; it is decanted and the crude phenic acid is distilled in a vacuum to give very pure phenol.

The Bergius and Meyer process enables phenol to be obtained by heating chlorobenzene with alkaline water under pressure at 300° C.

Pure phenol occurs in the form of white crystals with a characteristic odour, melting at 41° C. and distilling unaltered at 182° C. Humidity lowers their melting point and they may then liquefy. Phenol is slightly soluble in cold water, but more so in warm water; alcohol, ether, chloroform, and petrol; it is insoluble in acetic acid and the fatty oils.

**USES**

Phenol is used in the chemical industry for the preparation of numerous compounds and products, such, for example, as phenyllic ether or phenyl oxide, used in perfumery as the essence of geranium; hexaline or cyclohexanol, used for the preparation of emulsions with the mineral and fatty oils; salicylic acid, and numerous disinfectants and antiseptics known under the most varied names; it is also used in the rubber industry as "faturan".

Since 1911 very comprehensive researches have been directed towards obtaining new synthetic tannins, organic products more or less defined, which possess the property of combining with proteinaceous matter, such as gelatine and hides, and giving rise to imputrescible substances which possess some resistance to the action of water.

These new synthetic tannins may be classified in two categories, according as they are related to (a) condensation products of sulphonated aromatic carbons or of sulphone phenols with themselves; or (b) condensation products of sulphonated aromatic carbons or of sulphonated phenols with formol or another aldehyde. The products at present existing on the market under the most varied names belong almost entirely to the second category. They correspond principally to various types of condensation of formol with the sulphonated phenols and, in particular, with crude sulphonated cresol.

"Acrolite" is an artificial resin based on phenol and glycerine, with 4-12 per cent. of formaldehyde. It is used for impregnating fabrics or sheets of paper and asbestos, and for making moulded objects which are unattacked by chemical agents and resist high temperatures.

For industrial hygiene and pathology relative to the substitution products of halogenated phenol, reference should be made to the corresponding articles. It is sufficient here to say that many of these products are used in the chemical industry for the preparation of synthetic organic dyes, synthetic medicaments and organic developers used in photography.

Anisol, or methylphenic ether, is used as a solvent in the manufacture of certain chemical products and certain perfumes.

Trinitroanisol, or methyl ether of picric acid \((C_6H_4OH\cdot(CNO)\)) is used in the chemical industry and especially in the manufacture of explosives.

**SOURCES OF DANGERS**

**During preparation.** — The risk arises chiefly from the operation of sulphonation (synthetic phenol). (For dangers during the distillation of coal tar, see article "Coal Tar".)

**During use.** — Years ago the use of carbolic acid for disinfection during surgery (Lister's method, introduced in 1867) in the form of carbolic spray, was the cause of serious cases of poisoning among the medical personnel, both doctors and nurses. The use of its solutions for disinfection or preserving has been abandoned, and still is, the cause of cutaneous lesions.

Risks also arise during certain operations in the preparation, as well as in the use, of phenol compounds and chemical products with a phenol base: in factories for antiseptic dressings; in certain operations, such as the renovation of old rubber with phenol; in the manufacture of "faturan" and bakelite; and in the impregnation of wood by "carbineum".
Mention should also be made of injuries caused by the phenol released during certain operations: distillation of coal tar, if the phenol is not recovered; cleaning of the matter from purifiers for illuminating gas; treatment of ammoniacal liquor from illuminating gas. The ammoniacal liquor from the coke ovens of the Ruhr mines contains phenol, and endeavour is made to recover this by the use of benzol. It has been possible to push the recovery to such a point that there does not remain more than 0.7 to 0.8 grm. of phenol in the treated liquor. About 25 per cent. of benzol must be used to the quantity of liquor treated. There is left in the liquor 1.2 to 1.4 grm. of benzol, of which it is possible to recover about 75 per cent. Lastly there are risks of fire and explosion from trinitroanisol, which is an inflammable product.

**TOXIC ACTION**

The toxicity of the phenols due to the hydroxyl radicle increases with the number of these radicles. Hence pyrogallol, which is a trihydroxybenzene, is more toxic than phenol, which is a monohydroxybenzene (see also article “Benzene Derivatives”).

Phenol exercises both a local and a general effect. Locally it attacks the skin, for it precipitates and coagulates albumen. This caustic effect is naturally more marked on the mucous membranes, on which it causes burns and necrosis.

The toxic dose seems to vary greatly according to individuals. A large number of fatal cases are known from doses of 2 to 3 grm. But it is an accepted fact that 15 to 20 or even 30 grm. may be necessary to cause death. In industry as a general rule there only arises the question of poisoning by inhalation of phenol vapours. Reabsorption takes place, affecting chiefly the central nervous system; it is manifested by paralysis, preceded, in the case of animals, by intense excitement. Phenol, and especially the phenates, have a marked haemolyzing effect (Loewy) on the blood. According to the experiments of Paul Bert, the blood of the right side of the heart in cases of rapid poisoning is black; that of the left side is red. If phenol has been injected into the veins, the blood is black all over the body; it does not coagulate, but on exposure to the air it becomes red and coagulates. The red blood cells are changed. Sometimes fatty degeneration of the liver and kidneys is found. The urine develops a deep brown colour soon after taking the poison; elimination of phenol by the urine is therefore rapid. Hence Salkowski estimates that chronic poisoning by phenol is scarcely possible. On the other hand, there exists a definite tolerance in some subjects, so that many doctors using the carbolic spray never feel any ill-effects.

Part of the poison may be eliminated by the respiratory passages, and cause inflammation there. Phenol is found in the urine partly as such and partly as conjugated or sulphonyconjugated acid, or conjugated glycuronic acid. Falkson, after using for two and a half hours a 2 per cent. carbolic spray, eliminated in twenty-four hours 2.06 grm. of phenol, or fourteen times the maximum dose used at that time in the pharmacopoeia.

The chlorinated and nitrated compounds of phenol have a caustic effect analogous to that of phenol and perhaps even more pronounced. In animals the mononitrophenols transform haemoglobin into methaemoglobin.

No case of industrial poisoning is known from chlorophenol (ortho or para) which has a certain practical interest, since it is used in the manufacture of antiseptic products, and of aniline dyes.

From experiments (Karpow, 1893, and Binet, 1896) they appear to cause muscular spasms, trembling, collapse and then death. There is no difference in the action of the two isomers. The kidneys are the most affected (haematuria and casts). Chlorophenol and trichlorophenol have a greater caustic effect than phenol; their fumes irritate the conjunctiva and cause severe lachrymation (Erben).

Dambloff (1908) caused the death of a rabbit by applying on the skin ortho-nitroanisol in the dose of 0.5 grm. per kilogram of animal. Death was due to pulmonary haemorrhage. According to the French Committee on Munitions, dinitroanisol was one of the two most poisonous compounds with which it had experimented upon animals.

The aminophenols and the diphenols exercise a similar action. Trinitroanisol is distinctly less toxic than nitrophenol; but it has, nevertheless, a local caustic action and a general action, as became evident during the war in the manufacture of explosives and during the filling of grenades.
PHENOLS

STATISTICS

Cases of poisoning of occupational origin are very rare. Hamilton in 1880 reported three rapidly fatal cases which occurred in the United States: a chemist who had stepped into a small pool of phenol and splashed his leg, and two workmen whose clothes were splashed accidentally.

In Great Britain, Collis, in 1910, drew attention to some cases of eczema among workmen in the engineering industry who used mineral oils containing creosote and phenol. Bridge, in 1918, reported several cases of dermatitis with acute erythema and swelling of the face from phenol vapours. In 1923, there were reported two cases of multiple warts among young workmen employed in the extraction of creosote from wood.

This source of injury was also reported in Germany during the war. In 1913, in Passau, some cases of eczema were observed in a rubber factory where "faturan" was manufactured: three cases in 1912 and six in 1913.

In Upper Silesia, in 1922, several cases were reported of vomiting and malaise caused by a lacquer called "Phonol", containing tar distillation products and having a very distinct odour of phenol. This product had a strong irritating action on the skin. At the beginning of the same year numerous cases of eczema were reported in the Luneburg district in a rubber factory, and particularly in the marbling workshop, where umbrella handles were made by running a liquid mass of "faturan" into troughs and moulds. Six women workers out of twelve fell sick at the end of a few days. Whilst in 1913 the cases were due to phenol, in the instance in question the "faturan" contained neither phenol nor formaldehyde; but it is possible that the disease was due to a substance which was formed during condensation. Measures of protection were adopted, which included the application of lanoline on the forearms; these gave good results.

Numerous cases of dermatitis from condensation products with a basis of phenol or cresol and of formaldehyde were noted in Bavaria during 1923-1924, and also in Austria. In one factory the workmen who were the most exposed were those who washed the moulds containing the residue of a condensation product with a hot and concentrated soda lye.

In Switzerland, 3 cases of poisoning by phenol were reported in 1911 and 1 case in 1912; 5 cases of eczema or of burns in 1917-1918; 1 case of poisoning in 1926; 21 cases of eczema and burns from 1919 to 1925; 2 cases in 1926 and 1 in 1927 due to phenol and formaldehyde; 1 case in 1927 from nitroso-phenol.

Egli-Rust noted a fatal case, that of a railway worker who had dipped a finger into a solution of phenol, used for the impregnation of wood, and also cases of malaise (headache, vertigo) in work on artificial leather containing derivatives of phenol, liberated by heat and acid sweat.

In the U.S.S.R., Naumov noted in 1929 a large outbreak of poisoning among persons employed on impregnating wood with "carbolineum" (dermatitis, haemorrhage from the gums, nausea, vomiting and cough). On analysis, acridine and anthracene were found to be present in the "carbolineum".

PATHOLOGY

The local effect of dilute solutions of phenol on the skin is shown by dermatitis, with exanthematous, macular and papular erythema, by paraesthesias which may extend as far as loss of sensation, by tingling, pigmentary changes, and loss of the normal softness of the skin, which takes on the appearance of parchment, and becomes yellow and yellowish-brown. The more concentrated solutions cause burns, with the formation of white dry scars, which later turn yellowish-brown. Very high concentrations cause more or less deep erosions, which pass on to gangrene. Healing may be obtained by eliminating the necrotic parts, with cicatrical contraction; but cases which have ended fatally are known.

Among medical staffs a true eczema, which spreads rapidly and is increased by an individual susceptibility, has been observed (Blaschko).

A special sequela is phenic chromosis, a melanotic coloration of the cartilaginous or similar parts of the body, as well as of other parts, including the face, external ear and hands; it is the result of chemical reactions with transformation of the colouring material of resorcin and hydroquinone by a ferment, tyrosinase.

Occupational poisoning by phenols is not very common. The acute or subacute form may appear in the case of extensive and strong splashing with the product; it then occurs in the form of an accident (breaking of a carboy or some other apparatus). The symptoms described are: loss of consciousness, death from respiratory paralysis, preceded by muscular spasms and convulsions. In the less serious cases burning and noises in the ear are noticed, headache, vertigo, fainting, mental confusion, excitement, delirium, pallor of the face, dyspnoea, irregular respiration, with small pulse, phenomena of excitement, enlargement of the pupils, and then paralysis and death.

These symptoms have been caused also by the inhalation of phenol vapours, which irritate the mucous membranes and may engender catarrh and erosions of the respiratory passages, with laryngitis, tracheitis, bronchitis...
and broncho-pneumonia, and affect the eyes, setting up conjunctivitis, keratitis and leucoma, especially among workmen employed in mixing tar, and the oils of tar, with phenol for impregnating wood. The damage is particularly serious when splashes of phenol enter the eye. Cases of oitis caused by phenols have also been reported.

Many authorities at the present time fail to admit that there exists a chronic form of poisoning. However, a chronic general form, known as "phenic marasmus" was described by Czerny for the first time in 1882 among doctors and their assistants who used the carabolic spray regularly. Von Jaksch has also described it among workmen employed at factories where carabolic dressings are made. This marasmus is characterized by digestive symptoms, including serious disorders of nutrition, with vomiting, difficulty of swallowing, ptomaine, diarrhoea and anorexia, by nervous disorders, with headache and mental disturbances, and by sexual symptoms — vertigo, fainting and skin eruptions of every kind. In serious cases degeneration of the kidneys, causing chronic nephritis, and of the liver has been described. When these symptoms appear, the development is usually fatal. The authorities previously mentioned consider that more doctors than is generally recognized have died in this manner in consequence of the regular use of the carabolic spray.

As regards the local and general action of nitrated phenols, the reader is referred to the article "Dinitrophenol".

Of the aminophenols, amido exercises a local caustic action on the skin, and originates paraesthesia, as well as signs of irritation of the mucous membranes. Metol causes eczema, chiefly in blond people (for full details, see article "Aminophenols").

Hydroquinone and resorcine exercise a similar action. During their manufacture, scrotal hyperkeratosis and an effect from reabsorption, similar to that of phenol, have been noted.

Guiacol causes diminution in the sensibility of the skin, and sometimes eczemas, vesicles and superficial necroses. In stronger doses, the effect of absorption is to cause attacks of sweating with a fall of temperature, polyuria and pyrexia.

Creosote causes very irritable lesions of the skin, with eczema and erythema, especially when hot. Legge has seen some cases of this in needle factories, caused by oils of tar containing creosote. Exposure to creosote fumes leads to a brown coloration of the cornea, and, after long exposure, to desquamation of the corneal epithelium.

Local effects on the mucous membranes of the conjunctiva, nose and pharynx, have also been described. Cookson reported, in 1924, the case of a workman who was exposed for many years to the action of creosote; he had an epithelioma on the right hand complicated by warty excrescences on the left arm. The course was rapidly fatal.

Among the trivalent phenols, may be mentioned pyrogallol or pyrogallic acid, the local effect of which is shown by erythema, dermatitis and burning, while the general effect is shown by headache, shiverings, vertigo, vomiting, diarrhoea, pallor, anuria, diathesis, diarrhoea, pallor, thirst, feeling of malaise and lassitude, headache, vertigo, anorexia, thoracic constriction, restlessness, rise of temperature, and, in serious cases, inflammation of the lungs and haemorrhagic nephritis. Cessation of work and suitable treatment arrests the malaise in two to three weeks. No special sequelae have been observed. It is, however, to be noted that a special sensitiveness of the skin remains, not only to trinitroanisol, but also to various other chemical substances which are of themselves only slightly irritating (Koelsch).

In the case of poisoning by phenols, the urine is pale yellow or bloody or reddish brown, turning, on exposure to the air, greenish-black. Urine treated by barium chloride does not give a precipitate of barium sulphate, for all the displaceable sulphate is used to
form phenol-ethersulphuric acid. The urine also often contains albumen and casts. As regards the chlorinated compounds, see above.

DETECTION

In addition to their special and very characteristic odour, the phenols have various reactions which make their recognition easy. The most convenient process of estimation consists in transforming phenol into tribromophenol, and measuring the quantity of bromine water required for this transformation. (See text-books of chemical toxicology.)

HYGIENE

Scrupulous personal cleanliness is required, and also adequate organisation of first aid; some firms provide a supply of alcohol for immediate removal of splashes caused by phenol.

All the measures proposed for the manufacture of chemical products, and, in particular, of nitro and amino derivatives, should be applied in the preparation and manipulation of phenol.

Nowadays, such up-to-date apparatus is used that any escape of the product is almost completely precluded. Recourse should, however, be had to localised exhausts for the fumes whenever that is possible. Work in glass cages with openings for the passage of the arms has, in some cases, been effectively employed.

Dephenolisation of waste water is of the first importance from the point of view of hygiene and of industrial economy. Phenols are found in large quantities in water used for scrubbing and condensing illuminating gas, and at cokeries, but mainly — it may even be said almost entirely — in water from the condensation of refrigerants. Hence the need for collecting this water separately, so as to treat smaller, but richer, quantities of liquid, use less solvent, and obtain a higher output. It is estimated that as much as 99 per cent. of the phenols — that is, of phenol and cresols — can be recovered.

The methods of dephenolising can be classified in two groups: first those where the destruction and elimination of the phenols does not permit their recovery, the use of water for quenching coke, sending water into a tower in order to bring it into contact with fumes or combustion gases, or treatment by a biological process with Emscher's filters, and secondly those which permit recovery. After clarification and exhaustion with benzol, with the addition of sulphuric acid, the benzene solution is treated by a caustic alkali (method of Weiss). The phenol is found in the water, either as such or in the form of calcium phenate, when the water has had lime added to it in order to liberate the combined ammonia.

Replacement of toxic products by others not having the same disadvantages should be resorted to wherever possible. Other measures recommended are the use of means of protection for the workmen (application of lanoline or other fatty substances), the selection of workmen after medical examination, with elimination of sensitive subjects and periodical medical supervision.

LEGISLATION

Legislation is the same as that laid down for chemical products in general and for nitro-amido derivatives of benzene and their homologues (see those articles).

The Argentine Government excludes women from any work which brings them into contact with phenols and cresol; likewise in Japan, young persons are excluded from operations which involve contact with phenols. In the Netherlands the law protects adolescents and women (Decree of 1920), working in places where they are in contact with these products. Cases of poisoning by phenols are compulsorily notifiable in U.S.S.R., and there is compulsory compensation in Finland and Switzerland.

It must, however, be noted that skin lesions and poisoning by phenols are compensated under laws which compensate dermatitis due to chemical products, as well as poisoning by the nitro-amido derivatives of benzene and their homologues, and laws which compensate occupational diseases by "definition".

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Phenylhydrazine


Hydrazines are obtained by reduction of salts of diazonium with a hydrochloric solution of stannous chloride. By replacing this stannous chloride by sulphite of soda, there is obtained the diazoureasulphinate, which, by the addition of zinc and acetic acid powder, followed by boiling with hydrochloric acid, separates out the chlorhydrate of phenylhydrazine.

Phenylhydrazine \((\text{C}_6\text{H}_5\text{N.H.NH})\) is obtained from chlorhydrate treated with an excess of caustic soda at 30 per cent., after cooling it is extracted with benzol from which it is separated by distillation of the solvent in a vacuum.

It is an oily, colourless liquid which turns brown on exposure to air. When it is very pure phenylhydrazine takes the form of a colourless crystalline mass which melts at 19° C. and boils at 243°. With powerful reducing agents it furnishes aniline and ammonia. With nitrous acid it gives nitrosophenylhydrazine, which is highly toxic.

Amongst the other compounds of this group mention need be made only of \(\beta\)-phenylhydroxylamine, which is obtained by oxidation of aniline or by a reduction of nitrobenzene with zinc powder and water.

Phosgene

(Carboxyl Chloride, Carbon Oxychloride)


PROPERTIES

Phosgene is the name commonly given to carboxyl chloride or carbon oxychloride \((\text{COCl}_2)\). It was discovered in 1812 by J. Davy, who prepared it simply by exposing to the sun a mixture of one volume of carbon monoxide and one volume of \(\text{Cl}_2\), obtaining thereby one volume of \(\text{COCl}_2\). Hence its name of phosgene, which means “product of light”, derived from the two Greek words \(\phi\omega\sigma\nu\gamma\epsilon\mu\gamma\alpha\) and \(\gamma\epsilon\omega\zeta\alpha\omicron\nu\).

Phosgene is a colourless, pricking, suffocating gas with a disagreeable smell; it is three and a half times as heavy as air. At 7° C. it changes into a colourless liquid, very unstable, which has a specific weight of 1.433 at 10° C. and boils at 8.2° C. At -120° C. It solidifies in a snowy white crystalline mass.

Phosgene is a compound of slight stability: when heated it decomposes into carbon monoxide and chlorine. Hot water, and still better steam, decompose it quickly, giving carbon dioxide and hydrochloric acid \((\text{COCl}_2 + \text{H}_2\text{O} = 2 \text{HCl} + \text{CO}_2)\).

Metals (potassium, zinc, tin, etc.) at a high temperature fix chlorine from phosgene. Treated with cadmium sulphide at 270° C., phosgene forms sulpho-carbonic acid. According to Langenbech and Schumberg, phosgene is as readily formed as a product of decomposition of chloroform administered to patients in a room lit by petrol or gas. Certain surgeons have even attributed various disease symptoms to this gas, and cases of death after chloroform have been noted amongst patients and even amongst medical men and their assistants. Bréaudat, however,
never found that burning pure chloroform gave phosgene, but merely hydrochloric acid and a bitter and acid oil, containing perchlorated benzene, perchlorated ethylene chloride and chlorine. Another statement by Schumburg, to the effect that phosgene once absorbed into the system decomposes and gives off carbon monoxide, likewise remains without proof.

According to Glaser and Frisch, phosgene is also formed during the decomposition of carbon tetrachloride used as a fire-extinguisher. Similarly, phosgene is obtained when ultramarine is treated with carbon tetrachloride (CCl₄) and phosphorus.

Phosgene is readily soluble in the following products: glacial acetic acid, benzine, benzene, xylene, toluene, nitrobenzine, chlorobenzine, acetylene tetrachloride and numerous other hydrocarbons. Inversely it is one of the best solvents of certain substances, amongst which may be mentioned chlorine, chloropicrine, yperite (bichlorated ethyl sulphide) and hydrochlorate of diphenyiarsole.

Phosgene is sold in cylinders or in iron bottles after liquefaction by cooling to −35° C.; or dissolved in a 20 per cent solution of toluene. Thus dissolved it can be kept in glass tubes or flasks.

**PREPARATION**

The methods of preparing phosgene are numerous. From the time of Davy, who obtained it by the action of the solar rays, it has been prepared successively by making carbon tetrachloride at a high temperature act on carbon monoxide (Schutemberg, 1868), by means of phosphorus pentoxide (Gustarson, 1872), and by causing a mixture of carbon dioxide and chlorine to pass over incandescent powdered animal or vegetable charcoal and using an excess of carbon monoxide (Paternò, 1870). The reaction is more rapid and complete if red-hot platinum foam be used, but the process is more costly. Helbig in 1816 perfected the Paternò method and applied it in the manufacture of colouring substances, using as a catalyster small briquettes of very activated animal charcoal and pure carbon monoxide obtained by a special process. He later obtained (1917) phosgene at the Rumianca (Novare) factory by means of the following reaction: CO+SbCl₅=COCl₂+SbCl₃. But already in 1906 Michalske had manufactured it by heating in an electric furnace a mixture of quicklime, calcium chloride and powdered coke. With this reaction carbide remained in the calcium furnace and phosgene was given off. During the war phosgene was manufactured in several countries by a method that was simpler and quicker but more expensive and less efficient as regards output than the methods enumerated above. Fuming sulphuric acid at 100° C. (with 60-80 per cent. of free SO₃) was heated in iron boilers fitted with cooling apparatus, causing carbon tetrachloride to pass through the cooling pipes. The reaction was as follows: CCl₄+2SO₃=COCl₂+S₂O₅Cl₂ (chloride of pyrosulphuryl).

**USES**

During the war phosgene was one of the asphyxiating gases most commonly used by all the belligerents, either by itself or with other volatile substances, soluble in it (chlorine, yperite), with a view to increasing its deleterious properties.

On account of its capacity for disassociation it is largely used in the chemical industry for transforming into chlorides certain mineral oxides such as oxide of zirconium, thorium, uranium, cerium, ittrium, lanthanum, or to obtain anhydrous oxides of certain acids or hydrated oxides such as acids or oxides of vanadium, tungsten (wolframite), titanium and tantalum. It is also used for preparing numerous other products such as arsenic trichloride, acetychloride and acetic di-oxide; to effect synthesis of benzoic acid and benzo-phenone; in the treatment of phosphates and platinum ores; for the preparation of a great number of medicinal substances (dyphenylurea, duotal, creosotal, salol, urethane, etc.). The greatest quantity of phosgene is used, however, in the manufacture of aniline dyes derived from di- and triphenylnethane (diamethylaniline, Victoria blue, crystal violet, ethyl violet) and numerous azo dyes (true benzoic orange 8, wool yellow G, etc.).

**TOXIC ACTION**

The toxic action of phosgene on the system is similar to that of chlorine; the former is much more dangerous though the latter is more irritant.

It is estimated that the ratio of danger is about 15:1 and also that the risk from phosgene may depend on its tendency to cause pulmonary oedema.

The pathology of phosgene was first studied by Bréaudat (1892), then by Trümmler (1896) and Schumburg (1898).

According to experiments engaged in by Müller (1910) on rats and a cat with a view to determining the minimum fatal dose, the quantity of phosgene capable of killing rats in twenty-four hours was 0.02 per cent. in volume.
The numerous observations recorded during the war in cases of serious poisoning of large bodies of troops by asphyxiating gas did not always disclose the true nature of the gas. This explains why but little light has been thrown on the special pathology of phosgene. Experimental research by Lo Monaco and his pupils (Bilancioni and Sammartino) on white mice and rabbits has proved that the minimum fatal dose for white mice weighing 80 grm. is between 5-10 cub. cm., and for rabbits weighing 1 kg. between 15 and 20 cub. cm. With the maximum doses death occurred always within twenty-four hours.

As regards human beings, no certain data exist because, on the one hand, different individuals vary as regards their resistance to phosgene and, on the other, the degree of concentration of the gas in the atmosphere must be taken into account.

Koëbert states that human life is endangered by ten minutes spent in an atmosphere containing 450 mg. of phosgene per cub. metre of air.

According to the experiments of the American Bureau of Mines (1921), the physiological response to various concentrations of phosgene in the air are as follows: minimum quantity of phosgene detectable by its odour, 5-6 parts to a million of air; minimum quantity causing immediate irritation of the eyes, 4.0; of the throat, 3.1; causing coughing, 4.8; maximum concentration tolerable during prolonged exposure to phosgene, 1.0; dangerous quantity even for short exposure, 25; rapidly fatal, over 25 parts.

A unique opportunity for studying the pathology and morbid anatomy of phosgene occurred in May 1918, when an explosion took place in the neighbourhood of Hamburg in a depot containing about 11 tons of phosgene, during which ten people perished and thirty required hospital treatment (Heegler, Wohllwill, Mayer).

The experimental research effected by Winternitz, Wislocki and Finney on phosgene poisoning have shown that in dogs the consequences vary in accordance with the length of time the animal survives exposure to the gas. There is first of all pulmonary oedema with extreme congestion, which reaches a maximum towards the end of the first twenty-four hours and gradually disappears in the case of animals who live for ten days. There is besides fibrous exudation especially around the finer bronchial tubes, with resultant lobar or pseudo-lobar pneumonia, often complicated with necrosis of the walls of the bronchial tubes and formation of abscesses. Where recovery takes place there are sometimes zones of obliterating bronchiolitis and organised pneumonia, which may constitute focal of chronic infection.

Research of the same type effected by Achard, Leblanc and Binet on dogs and rabbits revealed, during the stage of acute pneumonia a marked increase of red corpuscles, of the haemoglobin and of the respiratory capacity of the blood representing a reaction of the system against asphyxia. At the same time polynuclear leucocytosis was noted on the day following exposure to the gas. In the week following the experiment there was often found increased coagulability of the blood and a slight diminution of the albumins in the serum; after disappearance of acute symptoms, progressive diminution of red corpuscles, of the haemoglobin and of the respiratory capacity of the blood, followed by a progressive anaemia which would appear to be of a toxic nature. The more intense the exposure to the gas, the slower the recovery.

STATISTICS

After the cases of Braudat, Trümmer and Schumburg there appeared in medical literature several cases of occupational poisoning by phosgene studied in 1906 by Klocke, in 1907 by Sury-Bienz, in 1910 by Müller (3 cases), in 1911 by Bender (3 fatal cases), in 1912 by Gremitske (3 cases), in 1914 by Roos (5 cases, 2 of which were fatal), in 1917 by Floret (1 case).

Legge in the reports of the British Factory Inspectorate, reported 27 cases of poisoning in 1917 and 69 in 1918 in munition and asphyxiating gas factories.

Three cases affecting chemists were studied in 1920 by Irene Gerbert and two fatal cases by Sheridan Delépine.

In the case, described by Osvaldo in 1928, of a worker who inadvertently caused a grenade to explode, there were chemical burns and serious ocular lesions (opacity and ulceration of the cornea, hypopyon, symblepharon), due perhaps to the presence of chlorine and bromine mixed with the phosgene.

SYMPTOMS

According to clinical observations made at the time of the explosion of the depot at Hamburg, and also during similar earlier occurrences, it appears that the odour of phosgene is discernible in the breath and clothes of the victims. However that may be, it is true that the skin and mucous membrane of the eyes and of the upper respiratory passages (nose and pha-
rynx) under the action of phosgene are subject to irritation only a little slighter than that provoked by chlorine. A short time after breathing phosgene, those affected suffer from a bad taste in the mouth and a smarting sensation in the throat, rapidly followed by more serious phenomena, particularly a dry cough and dyspnoea with a sensation of constriction of the larynx, respiratory exhaustion, suffocation, vertigo, nausea, violent pain in the epigastrium and often vomiting. In very acute cases oppression increases more and more, followed by cyanosis, especially of the lips and ears, profuse sweating and in four to six hours collapse and death by asphyxia. The immediate cause of death always seems to be intense swelling of the mucous membranes with bronchial spasm and consequent pulmonary oedema which interferes with the circulation of the blood and of the air in the lungs.

In acute cases which are not fatal phenomena of asphyxia mostly cease, within thirty-six hours, though the patient remains for a few days subject to respiratory oppression which obliges him to remain stationary in order to avoid dyspnoea and causes him to take very deep breaths from time to time. The cough returns in violent fits, similar to those in whooping cough; the expectoration is fluid with a sort of scum often mixed with blood. The temperature is mostly sub-normal. The pulse slow and strong.

Fairly frequently there is a daily rise in temperature up to about 38° C., followed by a drop. Albumin and casts are sometimes noted in the urine; the blood shows at first pronounced leucocytoses (Roos), then becomes viscous and thick.

Consciousness is always retained; there is never manifestation of nervous symptoms. Where no secondary infection occurs causing purulent bronchitis or pneumonia or broncho-pneumonia foci, complications which may cause a fatal issue of all these symptoms die down gradually in two to eight days, but complete cure is always tardy.

It has been considered possible to distinguish three typical clinical forms due to asphyxiating gas: super acute, acute and subacute effects of asphyxiations.

Poisoning by phosgene may obviously give rise to these same clinical forms.

For Meek and Oyster the physiopathology of phosgene poisoning has two chief aspects: (1) lesions of the deeper respiratory passages with inhibition and reflex vasoconstriction, alteration of the red corpuscles, capillary embolism, increased resistance of the small circulation and dilatation of the right heart; (2) transudation of the plasma into the sub-parenchymatous spaces and the alveoli, death due to fall in blood pressure and anoxaemia of the tissues.

Amongst numerous individuals inhalation of phosgene causes slight symptoms: (1) lesions of the mucous membrane, coughing, vomiting), followed by a period of well-being lasting some hours. Then suddenly very serious symptoms set in: dyspnoea, cyanosis, pulmonary oedema, which in serious cases lead to death (Ferraloro). This is explained rather by the greater resistance of certain individuals to inflammation of the respiratory mucous membrane with a consequent delay in the appearance of pulmonary oedema, than by delayed decomposition of the phosgene absorbed into the system and hence formation of carbon monoxide (as believed by Schumberg). This hypothesis is confirmed by the fact that the symptomatology takes a more serious turn in the case of fair and red-haired individuals (Heger). It has likewise been remarked that black cats resist poisoning better than white cats. Fairly strong doses of phosgene cause spectroscopic changes of the blood (presence of the rays of acid hematine and after reduction by ammonium hydrosulphide, of hematine reduced to alkaline solution or haemochromagen).

At the same time there is a disturbance of the liquid which the appearance under the influence of a slight excess of hydrosulphate (Kohn-Abrest).

Mayer (1928) attributes the formation of hematine to the action of hydrochloric acid resulting from the decomposition of phosgene in a damp medium: \( COCl₂ + H₂O = CO₂ + 2HCl \). Kohn-Abrest considers, however, that even in a case of death occurring in an atmosphere very rich in phosgene the chemical study of the blood will not, unless in exceptional circumstances, provide any useful data, the effects above referred to being only capable of detection in blood of which one-third at least is saturated by phosgene.

Autopsy of fatal cases discloses marked congestion of the larynx, the trachea and the bronchial tubes (Corcio, Wohwill), oedema of the glottis, sub-mucous and sub-pleural haemorrhages. The lungs are voluminous, the alveoli filled with a frothy liquid, and there are often small pneumonia or broncho-pneumonia foci and thromboses in the pulmonary arteries (Roos). As regards the other organs there is dilatation of the ventricular cavities of the heart (Müller) and fatty degeneration of the liver and kidneys, and slight
thromboses in the brain, intestines and limbs (Roos). Anatomical lesions in animal experiment (Müller, Lo Monaco) have confirmed the frequency of necrobiosis of the mucous membranes of the bronchial tubes and haemorrhages throughout the whole pulmonary field and have shown besides marked corrosion and haemorrhage of the gastric mucous membrane (Bilancioni, Sammartino).

Groll, on the basis of 150 autopsies on persons who succumbed to phosgene poisoning, distinguishes three forms of fatal issue: (1) death by asphyxia, characterised by chemical burns, congestive hyperaemia, oedema and pulmonary emphysema, which is equally sensitive to hydrochloric acid. Yet if litmus paper and another paper impregnated with Suchier's reagent be placed side by side in the same gaseous current, it is the litmus paper which will turn first if hydrochloric acid is present, and the dimethylinomobenzaldehyde if phosgene, which enables the two gases to be distinguished.

HYGENE

In industrial establishments where phosgene is prepared or handled, protection of the workers must not be restricted to the use of masks, since they can only be worn by workers employed for short periods and are therefore only to be used in exceptional conditions. It is essential therefore to adopt measures of hygiene calculated to ameliorate the surroundings: provision of adequate ventilation, of means for preventing escape of phosgene from closed apparatus and from piping, of exhaust plant for withdrawal of the fumes at their point of production, and of means for neutralising and decomposing them immediately by means of effective reagents (with a resorcin or phenol basis, with carbonate of soda, soda sulphophenate, mixture of carbon, soda and lime, etc.). Frequent change of working clothes is indispensable, especially since phosgene possesses the property of becoming fixed in materials. Frequent washing of the skin (douches and baths) is very effective, as is likewise the use of alkaline solutions for rinsing the mouth in order to prevent traces of phosgene dissolved in the saliva from causing irritation of the stomach.

Artificial respiration should never be applied to victims of phosgene poisoning (Ferraloro).

DETECTION

According to Kohn-Abrest, in detecting phosgene in the atmosphere an indication is provided by the symptoms produced by traces of this gas on the system. Traces of hydrochloric gas should then be sought for, coming from partial decomposition of phosgene fumes. If necessary, traces of hydrochloric gas can be got rid of by the aid of a piece of soda sulphate melted in its water of crystallisation; thereafter a solution of potassium is stirred with air to absorb the phosgene by decomposing it and forming chloride and carbonate. The presence of chloride in the alkaline solution is confirmed, and if possible that of the carbonate. This last fact is merely of value when the air studied does not contain unduly strong traces of carbonic gas.

Another method consists in desiccating the air by melted calcium chloride, passing it through absolute alcohol which retains the phosgene, and calculating the amount of chlorocarbonic ether formed in the alcoholic solution. A third method consists in shaking air in a tube with diluted potassium and then measuring first the chloride formed and as a control the amount of carbonate.

Kling and Schmutz have measured the phosgene content by combining it with aniline and finding out the weight of the diphenylurea precipitate. Suchier (1929) indicates the presence in a gaseous mixture (air) of traces of phosgene by using highly sensitised reaction paper impregnated with a mixture of dimethylaminobenzaldehyde and diphenylamine, which becomes yellow under the action of carbon oxychloride. The reagent is easily modified by the action of air and light and may turn yellow by spontaneous oxidation; for this reason it is essential that it should be prepared and stored under conditions which exclude atmospheric oxygen.

With a content of 1 c.c. per litre, it turns yellow almost instantly and in presence of phosgene; it requires twelve to fifteen minutes with an amount of 4 mg. per cub. metre. The reagent is equally sensitive to hydrochloric acid. Yet if litmus paper and another paper impregnated with Suchier's reagent be placed side by side in the same gaseous current, it is the litmus paper which will turn first if hydrochloric acid is present, and the dimethylinomobenzaldehyde if phosgene, which enables the two gases to be distinguished.

LEGISLATION

Legal measures for protection of workers against poisonous and asphyxiating gas are obviously generally applicable to phosgene.

In several countries storing and transport of phosgene are subject to special regulations dealing with poisonous gases (in Italy, for instance, under the Decree of 9 January 1957).
Those who come in contact with phosgene should be subjected to medical examination on engagement and to monthly examination thereafter to determine their state of health (such examinations have been made compulsory under Italian legislation: Ministerial Decree of 20 March 1929).

Cases of poisoning by phosgene are subject to compulsory notification in France and the Netherlands: they entitle the victim to compensation in Switzerland and in those countries in which compensation is afforded for poisoning by gas and fumes. Further, such cases may be considered as accidents and compensated as such.

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Phosphoretted Hydrogen (Phosphine)

French: Hydrogène phosphoré (Phosphamine).
German: Phosphorwasserstoff.
Italian: Idrogeno fosforato.
Spanish: Hidrogeno fosforado.

Properties

Phosphoretted hydrogen (formula PH₃) is a colourless, irritating gas, with a peculiar smell like rotten fish, heavier than air (1 litre weighs 1.52 grm. at 0°C. and 760 mm.). At ordinary pressure it liquefies at —85°C. and solidifies at —135°C.

It is only slightly soluble in water (0.1 volume in 1 volume of water — Zangger), rather more so in alcohol; it burns giving rise to phosphoric acid and, when complete combustion takes place, to phosphorus and water. The temperature of ignition is below 100°C with the pure product, but with impurities present (e.g. liquid phosphoretted hydrogen) it takes fire spontaneously at ordinary temperatures.

Mixtures of air and phosphoretted hydrogen are very unstable (with risk of spontaneous explosion), and this instability is greatly increased when the mixture comes into contact with different reagents (potash, potassium pyrogallate) or when the pressure of the mixture is reduced.

Chlorine, iodine and bromine destroy it readily; mixed with chlorine it detonates violently with formation of hydrochloric acid and trichloride of phosphorus.

It is absorbed by numerous solvents, copper sulphate, silver nitrate, sublimate, by the different kinds of charcoal (wood, coconut), bone black, etc. Nitric acid absorbs it in decomposing it, whence the use of this substance in the quantitative estimation of phosphoretted hydrogen. Similarly, it is absorbed and destroyed by the hypochlorites (used with a view to its technical purification). The best absorbent, however, is a solution of cuprous chloride in hydrochloric acid (1 volume of the solution absorbs 130 volumes of phosphoretted hydrogen without decomposing it). On heating or addition of potash this reagent gives off the phosphoretted hydrogen it has dissolved.

Phosphoretted hydrogen is a powerful reducing agent: use is made of this property to separate it from other gases containing it.

Sources of Poisoning

Poisoning occurs in the course of reactions in which phosphoretted hydrogen is given off as a by-product; and in the manipulation or the manufacture of chemicals containing phosphorus, because the latter combines as readily with hydrogen as it does with oxygen.

Such reactions may take place in the preparation in the laboratory of phosphoretted hydrogen and of phosphorus, the conversion of white into red phosphorus, the preparation of sesquisulphide of phosphorus, the action of acids on metallic sulphides, the reduction of silicate of iron containing phosphorus under the action of humidity, the use of cyanamide of calcium containing phosphate of lime or carbide of calcium, and the manufacture of acetylene with impure carbides of calcium containing calcium phosphates as the starting point. The amount of phosphoretted hydrogen in acetylene may be 0.02 per cent. (acetylene obtained from Swiss carbides — Wolff), 0.04 per cent. (acetylene obtained from American carbides — Wolff), or 0.06 per cent. (Lunge). Dittrich is even said to have found amounts varying between 0.8 and 1.7 per cent. Most countries have, however, placed a limit on the
phosphorus content of calcium carbide (this is done, however, more as a precaution against fire than on account of toxicity). A further source of poisoning is the preparation, storage or use of impure ferrosilicon made in electric furnaces (Holtzmann) (see the article “Ferrosilicon”).

“Simonal” is a mixture of silicon, aluminium, iron and ammonium treated in an electric furnace. Under the influence of damp air it gives off small quantities of phosphoretted hydrogen (in 1927 this gas caused three cases of poisoning, including one fatal, among the crew of a Rhine barge).

In 1929 sprinkling of a rat poison based on zinc phosphide on the floor of a Genoa factory where fish were pickled in acid brine led to several cases of poisoning, including one fatal. According to Zangger, the toxicity index is of the same order as that of hydrocyanic acid, perhaps slightly less for acute, and slightly more for chronic intoxication.

**TOXIC ACTION**

Phosphoretted hydrogen enters the system by way of the respiratory organs and is carried into the tissues by the blood, which is not modified although it readily absorbs the gas (about 0.27 volume of the gas in 1 volume of blood — Zangger).

The poison is also eliminated through the respiratory organs (in exhaled breath). According to Zangger, the toxicity index is of the same order as that of hydrocyanic acid, perhaps slightly less for acute, and slightly more for chronic intoxication.

The toxic action has been studied by numerous writers (Eulenberg, Hender- sen, Dybkowsky), but particularly by Lehmann and Yokote. According to the last two, relatively high doses can be borne for a short time without much damage by test animals. A strength of 0.09 mg. produced malaise for three days in animals after an exposure of 30 minutes. Death occurred in 30 minutes after exposure for 30 minutes to a strength of 0.06 mg. With 0.02 mg. it takes two and a half hours to kill the subject. Animals also die, if they absorb doses of 0.004 mg. several times a day and for several consecutive days.

Anatomical lesions are absent in acute, but are found in chronic, poisoning; they consist of haemorrhages in the respiratory organs, pulmonary oedema and fatty degeneration of the organs. A dose of 0.01 per thousand can be regarded as the most the human subject can tolerate. According to Thiele, a strength of 0.25 per thousand is fatal; 1 per 4,000 is injurious (Kohn- Abrest). Before death metabolism is notably reduced. Unlike arseniuretted hydrogen gas, phosphoretted hydrogen gas causes no alteration in the blood, although some writers maintain that it is a blood poison (Dybkowsky) with a haemolytic action (Koschlakoff and Popoff). Most authorities consider that the action of the gas is to paralyse the central nervous system after a period of excitation. Besides its toxic action in the doses indicated, phosphoretted hydrogen gas can give rise to explosions.

**STATISTICS**

Statistics are few. Glaister has reported two cases of poisoning among chemists handling the pure substance and Eulenberg one fatal case. Dietz and Huhne- feld have each reported a slight case. A fatal case has been reported in the Netherlands: a workman employed in welding a boiler with an oxy-acetylene flame. Most of the cases of poisoning result from ferrosilicon (see that article).

**SYMPTOMS**

The clinical picture resembles that of arseniuretted hydrogen. In severe cases the onset is sudden and occurs immediately after inhalation of the poison. The patient complains of tiredness, lassitude, anxiety, oppressive- ness, preternial and diaphragmatic pain, soon turning to a burning sensa- tion and taking on a lancinating char- acter, disturbed respiration, buzzing in the ears, rigors, vertigo, etc. Some- times pulmonary lesions are found (inflammation or oedema), also symp- toms pointing to involvement of the central nervous system, such as nausea, vomiting, staggering gait, tremor of the extremities, dilatation of the pupil, cold clammy sweat, clonic and tonic convulsions. When the intoxication is fatal, weakness increases. There is loss of consciousness, collapse, failure of the pulse and respiration, unconsciousness and delirium, coma and death.

In slight cases there is bronchitis, and the illness usually passes off without complications.

Accurate diagnosis cannot be made without knowledge of the possibility of inhaling the poison as no trace of it is found in the body.
PHOSPHORUS

DEMONSTRATION

(a) In the air: this is carried out (according to Kohn-Abrest) as for arseniuretted hydrogen (see that article).

Another reaction consists in passing the air to be analysed into a solution of silver nitrate, which absorbs the phosphoretted hydrogen and decomposes it. Two-thirds of the phosphorus is precipitated as silver phosphate; the rest remains in solution in the phosphoric acid and phosphorus can be detected by the ordinary reagents.

According to Lehmann it is necessary to bubble the air containing phosphoretted hydrogen into bromine water, remove the bromine, precipitate by a mixture of magnesia the phosphoric acid formed, which is thus identified.

(b) In the body: Gleister states that phosphorus has been identified by means of the Marsh apparatus (animal tests).

PHOSPHORYICATION

As regards first aid and prevention, see article "Ferrosilicon".

In exceptional circumstances, however, gas masks can be used as means of prevention. Exhaust ventilation should be downwards as the gas is heavier than air.

LEGISLATION

Poisoning by phosphoretted hydrogen is compulsorily notifiable in the Netherlands. Compensation is granted in countries where poisoning by toxic gases is compensable, and by those in which phosphoretted hydrogen is specifically mentioned in the list (Finland, Switzerland).

Prof. H. Zangger
(Zurich).

Phosphorus


Phosphorus (symbol P) is a metalloid which is not met with in the free state, but only in very numerous geological formations in the form of phosphates (especially tricalcic phosphate or phosphorite) or of other mineral phosphates, such as apatite, vivianite, wavellite, etc. It is also present, but in small quantities, in rocks, fertile soil, the sea, in all vegetables whence it passes into the animal frame, localising itself especially in the bones of vertebrate animals as tricalcium phosphate. Traces are found also in the air.

CHEMISTRY

Solid at the ordinary temperature, phosphorus freshly prepared is colourless. Sunlight turns it yellow; and it then becomes covered with a pinkish white opaque film. Its atomic weight is 31.0; its specific gravity 1.83 at 10° C. Soft like wax, phosphorus becomes hard and brittle when cold; has a garlic-like odour; melts at 44.46° C. and boils at about 290° C. At 34-40° C., on contact with the air, it ignites spontaneously and burns with a luminous flame; it gives off white fumes, phosphorescent in the dark, which are formed by the oxidation of the phosphorus vapour, and consist of phosphoric and phosphorous acids and phosphorous vapour. If the air is moist, ozone, peroxide of hydrogen, and nitrate of ammonia are produced at the same time. It is insoluble in water, very slightly in alcohol (0.3 per cent.) and ether (1.13 per cent.); it dissolves better in turpentine (4 per cent.), in oils (2 per cent.) and fatty substances, and very readily in carbon bisulphide, chloroform and chloride of sulphur.

MANUFACTURE

Discovered in 1669 by the alchemist Brandt (of Hamburg), who obtained it by heating urine with sand, it was for the first time extracted from bones by Scheele by the method used to-day.

Industrially, phosphorus is produced from the natural phosphates (or from bones that have had the grease removed and been calcined in furnaces), by treatment with sulphuric acid which converts carbonate of lime into insoluble sulphate and the neutral phosphate of lime into the acid phosphate. The solution is filtered and the concentrated filtrate is mixed with coke or sawdust and treated in muffle furnaces. A red heat is applied in earthenware retorts and the distilled product is condensed in iron pipes. The phosphorus, still contaminated by coal particles, is purified by distillation with steam in an atmosphere of carbon dioxide or by filtration through a porous plate of clay, covered with a layer of animal black, or finally through chamois leather. The liquid product is finally run into cylindrical form or into blocks, under warm water, by the use of moulds of the required shape.

Nowadays the method of Wöhler is preferred, which employs bone meal and allows of the extraction of 80 or even 92 per cent. of the phosphorus therein contained. This method is applied also to natural phosphates. The process consists in heating in an electrical furnace at 1300°-1450° C. a mixture of the bone meal, quartz sand, and coke. The furnace is hermetically closed and communicates with a conden-
ser; the silica attacks the phosphate of lime, converting it into a silicate and setting free phosphorous pentoxide which, attacked by the carbon, forms carbon monoxide and phosphorus according to the following reaction:

$$2\text{Ca}\left(\text{PO}_3\right)_2 + 6\text{SiO}_2 + 10\text{C} = 6\text{CaSiO}_3 + 10\text{CO} + 4\text{P}.$$  

The phosphorus, in the form of vapour mixed with carbon monoxide, arrives at the condenser where it is immediately condensed and run under water, whilst the silicate of lime remains as a residue in the furnace.

Phosphorus must always be kept away from air. For this reason it is always marketed in water (with small quantities of alcohol or glycerine to prevent freezing) and packed in well-closed metallic receptacles, which again are placed in very solid wooden boxes or small barrels painted outside with tar and wrapped round with straw and canvas.

Phosphorus is marketed in two forms as white or yellow phosphorus and red phosphorus.

The first is ordinary phosphorus such as is obtained by the methods described.

**Sources of Poisoning**

Crushing of bones gives off much dust if adequate precautions are not taken.

During the treatment of the bones, nauseous fumes are given off during the reaction, due especially to phosphoretted hydrogen and carbon monoxide. Treatment of the mixture by sulphuric acid also gives off sulphuric hydrogen, carbon dioxide, hydrocyanic, hydrochloric and hydrofluoric acids. The phosphorous fumes can vitiate the air of the workroom if suitable preventive measures are not taken. This risk is similarly present in all the industries which manufacture or use phosphorus and its compounds. Another danger exists in the use of solvents, especially carbon bisulphide, which, mixed with the phosphorus, is a very common cause of fire.

The workrooms and especially the evaporating and drying rooms are very humid, and in others the temperature is relatively low.

**Uses**

For most purposes white phosphorus is now replaced by the red, and in the factories which manufacture it, it is almost entirely converted into red phosphorus. It is, however, still used in the preparation of certain compounds of phosphorus, of certain synthetic colours, bronzes and phosphides (see articles "Phosphorus (Compounds)"); in metallurgy; in the manufacture of liquid and incendiary projectiles, smoke screens, etc.; in the manufacture of manure, of powders against pests such as rats and mice, of artificial fires, of paraffined strips of phosphorus paste for relighting miners' lamps, alloys, etc.

Phosphorus in the form of fumes or of its compounds may be present in other industries or processes. Thus, for example, it can be given off, under certain conditions, from ferro-silicon in the form of phosphoretted hydrogen (see that article), and may be contained as an impurity in acetylene (see that article).

The number of persons, however, coming into contact with phosphorus at the present time is very limited; further, as the processes are almost all mechanical, the risk of poisoning by phosphorus is very much reduced.

**Toxicity**

The toxicity of chemically pure phosphorus, minimal so far as the element alone is concerned, is very remarkable when it is a question of the oxides. Phosphorus fumes are the product of the slow combustion of phosphorus exposed to moist air. The toxic agent, however, has not yet been identified, as the determination of the products which are formed by the oxidation of phosphorus has not yet been effected. Certain authorities attribute the toxic action to phosphorus, while others incriminate phosphoric acid and still others phosphoric acid (at a dose, however, three times that which suffices to produce death with phosphorus). The fatal toxic dose is given by certain authorities (Kobert) at 5 centigrams, by others at 20 centigrams, whilst Kobert considers that a dose of 1.5 centigrams is sufficient to cause serious illness. Ogier is of opinion that 5 centigrams of phosphorus may exceptionally cause damage, but that in an adult poisoning is not caused except by a dose of 20 to 50 centigrams. Children are affected by smaller doses (from about 10 to 15 mg.).

No difference has been noted in the two sexes in susceptibility to phosphorus; the general state of nutrition is of little importance; age is of slight importance, although persons under eighteen years are said to be particularly sensitive. Poisoning, however, is more frequent among persons aged 30 to 40 years, perhaps because it is then they are most exposed to the risk in their profession.
An hereditary predisposition has not been proved. The frequency of morbid signs in the same family can be explained by living together and intimate contact, especially through the work-clothes brought home, and a certain family weakness in certain organs or tissues is recognised. The influence of individual susceptibility, which in some persons can reach a high degree, is evident.

Phosphorus reaches the system, especially in the form of vapour, mainly through the respiratory tract, and through the digestive tract when foodstuffs or fingers carried to the mouth are soiled by particles or even phosphorus fume. The skin can only very rarely be a channel of absorption.

The presence of fatty substances in the stomach favours the absorption of phosphorus which is dissolved in the intestinal juices, thanks to the bile. Part of the absorbed phosphorus undergoes change and part is dissolved in the tissues and is found in the blood whence it is eliminated in the form of phosphate. The principal channels of elimination are the kidneys, the lungs and the skin. Phosphorescent phosphorus from bones; in France, since 1880, 9 cases have been reported in the chemical industry; in 1897 Haup traced a

Phosphorus poisoning may be either general (phosphorus cachexia) or local (necrosis of the maxillary bones). The origin of the latter form can be explained by three theories: (1) as a selective action of phosphorus on bone; (2) as a gingival or periosteal infection, or (3) as a sequela of dental caries. Generally it is difficult to decide whether the toxæmia always precedes the local manifestations or whether the phosphorus acts directly on the gingival mucous membrane and bones with or without the association of a local predisposition or pre-existing inflammation.

If the reproduction experimentally of phosphorus necrosis has failed, Vallardi has nevertheless shown that, in the absence of necrosis, changes in the blood, organs and nutrition, characteristic of phosphorus poisoning, are found, while the majority of authorities are agreed that the harmfulness of phosphorus is attributable to the fumes (oxide of phosphorus) on carious teeth or on lesions, small though they may be, of the gums and periosteum. Perussia has proved that the changes in the maxillary bones can be observed even without dental caries and periostitis. When an individual, as a consequence of nasal defects, is compelled to breathe through the mouth the phosphorous vapour comes in contact more easily with the carious teeth and exerts its pernicious action on them the more readily.

Phosphorus, in passing over the soft tissues, might bring about changes in the nutritive processes of the external membrane of the bones. The bones of workers in match factories suffering from necrosis and not completely recovered are said to be more fragile as a consequence of a general morbid state, of which the picture is not that of a simple local infection. The bones of these workers are said to contain an excess of phosphoric acid. The adversaries of the dental caries theory think that a gingivitis takes on a septic condition which degenerates into an osteitis. Actually the general conclusion is that the phosphorus itself does not set up necrosis of the bones, but that it is the predisposing cause of primary lesions which later on develop, especially as the result of inevitable infective complications. Removal of the patient from contact with phosphorus serves to arrest a periostitis which is in the stage of evolution, even if it has already gone on to an ossifying periostitis. Phosphorus fumes would then have a simple secondary action.

Persons engaged in the manufacture of phosphorus are also exposed to the risk of poisoning from acid fumes, from carbon bisulphide and phosphoretted hydrogen (during distillation), and eventually from arsenurettet hydrogen.

**Statistics**

Occupational phosphorous poisoning was not coincident with the discovery of the element, but developed 150 years later with the discovery of matches (1833) (see article "Matches [Lucifer]").

Cases of phosphorous poisoning, however, have been reported among workers manufacturing phosphorus, and in industries and trades using it. Pieraccini cites cases among workmen in factories making phosphorus from bones; in France, since 1880, 9 cases have been reported in the chemical industry; in 1897 Haup traced a
case to the manufacture of phosphor bronze (0.76 parts of phosphorus to 100 parts of alloy). In Germany, in 1913, of two cases among 70 workers in a factory for making lights for miners' lamps, one recovered after 50 days sickness, while the other was permanently disabled. A third case which occurred in Saxony was that of a worker employed as a spinner in whom the disease developed three months after cessation of work; illness lasted 114 days. A fourth case was reported in Bavaria in 1919, but no cases have been notified recently in Germany from the manufacture of phosphorus, although the output has been very great.

Koelch stated that 12 cases occurred in Germany during the war.

Three cases of necrosis were recorded from 1920 to 1926; 12 cases of phosphorous poisoning were reported from 1926 to 1929 (only one compensated).

The cases in Austria were due to phosphor bronze.

From 1927 to 1929 one case “probably” due to phosphorous was reported.

In the United States (New Jersey) cases of necrosis have been traced recently to a factory for fireworks.

Five cases of necrosis were reported in France (1927) among workers in a white phosphorus factory (Borard and Durnel); one case in a woman was caused by making phosphorescent lighter for miners’ lamps.

In Great Britain cases of phosphorous poisoning have been more frequent than on the Continent (see the Report by Thorp, Oliver, and Cunningham of 1898). They state that in the course of 50 years 17 cases were reported in a phosphorus factory using apatite as the raw material. From 1915 to 1919 the total cases of phosphorous necrosis coming to the knowledge of the Factory Department were 21 (with 4 deaths), of which 12 (with 1 death) occurred in the manufacture of phosphorus. It is interesting to note that after 1915 cases occurred among workers employed at the condensers and that two were reported among those engaged in making amorphous phosphorus. Since 1919 no case has been reported.

In the U.S.S.R., necrosis was found in two men who had worked fifty-two and sixty-three years respectively in match-making (1926, Asbel). The illness had begun forty years earlier and was exceedingly chronic. Several of these men’s workmates had died in the meanwhile from phosphorous necrosis.

In 1929, Schritter reported necrosis in a workman who had been employed for four years in the department of a chemical works manufacturing red and white phosphorus and phosphoric anhydride.

**Symptoms**

Locally, phosphorus sets up burns and painful caustic lesions, which heal very slowly; cases of dermatitis (on the hands, fingers, and feet) are described as well as conjunctivitis; itching, burning sensation in the tongue and throat, loss of appetite, air hunger, nasal irritation, cough, etc., have been stated to occur in workpeople preparing rat paste or powder.

In acute or chronic poisoning after ingestion of phosphorus the morbid symptoms come on very rapidly—in the acute form mostly after a few hours—and are noted throughout the whole duration of work on the unhealthy process. In chronic poisoning (manifested in the form of necrosis), on the other hand, the symptoms do not appear until after several weeks (7 weeks on an average), and even generally not until after several years (on an average 4 to 6 years) of exposure to risk. Not infrequently cases are reported with duration of employment of 18, 25, and 30 years, and even in workpeople who have left the work for several months or years (frequently 4 and sometimes after 8 years). These late cases are usually severe.

Two anatomoclinical forms of phosphorous poisoning, therefore, can be distinguished: the acute form, fairly frequent as an accident, and the chronic, which is peculiarly industrial.

The onset and course of the acute form can sometimes be rather slow with subjective symptoms—bad taste in the mouth, allaceous or garlic-like taste more or less marked, developing some hours after ingestion of the poison and (as an objective symptom phosphorescence of the breath in the dark) followed by a feeling of numbness, constriction and pain at the back of the throat, along the oesophagus and in the epigastric region. Subjective symptoms supervene then: nausea, biliary vomiting, haemorrhages occasionally, pains, colic, hiccup. The vomit is black with garlic-like characteristic smell, phosphorescent in the dark; the blood in it is often abundant but rarely red in colour. Sweating is more or less abundant, thirst intense and diarrhoea rare, giving place to constipation or more often the one alternating with the other. The faeces are also phosphorescent and often bloodstained.

An almost complete period of remission follows in general and the patient appears cured. But after two or three days, in about half the cases, a second period develops, of which the most important symptom is an intense jaundice—sometimes limited at first to the conjunctiva and extending thence to the whole of the body. Biliary pigment is formed in the urine; the faeces are pale and clay-like. The liver and spleen become enlarged. The urine becomes scanty (or there is even suppression),
with choluria, albuminuria, often haematuria and even the presence of leucin and tyrosin and rapid diminution of the urea. The temperature falls, the pulse becomes feeble and slow, and collapse and lipothyemia are frequent and sometimes precede the fatal issue. Respiration becomes rapid, with dyspnoea, which is perhaps due to the change in the blood. At this stage subcutaneous haemorrhages occur, digestive disturbance (nausea, vomiting and diarrhoea), photophobia (with myosis). Rise in temperature may occur but is unimportant. Severe lightning pains in the head, along the vertebral column, in the epigastrium, etc., are described, as well as painful cramps and contractions in the limbs. The sufferers are hypersensitive and over-excited (hallucinations, delirium, and insomnia).

There follows a state of depression very marked and characteristic. Further, there is loss of sensation in the skin, dilatation of the pupils, abolition of the reflexes and localised paralysis. The fatal issue is ushered in by collapse or syncope (paralysis of the vagus or internal haemorrhages in the brain or lungs) and is sometimes rapidly induced by severe haemoptysis.

The course of acute phosphorous poisoning does not usually last more than a week, rarely two or several weeks, with a subacute form characterised by alternating exacerbations and remissions. Where there is recovery the kidneys, liver or the myocardium may be the seat of permanent degenerative lesions.

If the haemorrhagic and nervous phenomena take the principal place in the clinical picture the poisoning is either of haemorrhagic type (with vasodilatation of the skin and digestive tract, purpura, ecchymoses, epistaxis, melaena, gangrene) or of nervous type with fatal issue in a few hours, preceded by muscular paralysis, peripheral neuritis, painful cramps, somnolence, delirium, convulsions and very intense jaundice. In the nervous type mortality is very high (one-quarter of those affected).

A special form with symptoms belonging both to the acute and chronic conditions is characterised by loss of appetite, gastric pain, colic, headache, cough, muscular pains, etc. It is met with especially among workpeople coming for the first time into contact with free phosphorus, and disappears, generally after a little acclimatisation, but there remains a tendency to catarrh, bronchitis, gastric pain, and colic. Persistence of these symptoms is there fore in the majority of cases a sign of chronic poisoning.

This chronic poisoning occurs in two forms:

(a) A general chronic condition, the onset of which is characterised by digestive troubles, blood changes (increase in the number of white blood cells and leucocytes, especially of sudanophiles (Biondi), more pronounced and widespread degenerative changes in the leucocytes, which have polymorpho-nucleares and which appear loaded with fat) and by qualitative changes in the urine (presence of free phosphorus, of urea in excess, but rarely of sugar). The excreta and breath have a garlic-like smell. The sufferers complain of loss of appetite, dyspnoea, vomiting, diarrhoea. Swallowing is difficult as a result of complications affecting the nose, tongue and pharynx. A chronic condition of the back of the throat and pharynx is common as well as bronchitis and broncho-pneumonia. The liver and kidneys present the same lesions as those which have been described under the acute form. Fragility of the bones, anaemia with pallor of the mucous membranes and a jaundiced tint of the skin, tired eyes, fever, hesitation in speech, mental dulness, general weakness and insomnia complete the morbid picture. Phosphorus seems to absorb all the faculties and to cause a loss of energy and courage for work.

(b) A localised form, of which the typical symptom is necrosis (phossy-jaw) generally a late symptom. This form was described for the first time in 1845 by Lorinser of Vienna, and then by Heyfelder (Vienna), Erlangen and Strohi of Strasbourg, it was made the subject of a classical monograph by Bibra and Geist published in 1847. The necrosis is ushered in by pain like that of toothache, followed rapidly, however, by swelling of the gums, which become red and bleeding: this is alveo-dental periostitis. In most cases the tooth, often carious, is extracted and pus wells up out of the alveolar cavity. The lesion affects also the gum and the sound teeth. In spite of the extraction the pain does not stop but on the contrary gets worse and extends to other teeth which in their turn have to be extracted. Pain and suppuration continue. The teeth loosen, the gums and surrounding tissues become inflamed, ulcerated and a prey to supplicative processes — a sign of the destruction of the jaw-bone — which make their way through the cheek by fistulous tracts. The sufferer experi-
ences difficulty in opening the mouth, in speaking and eating. Sometimes particles of bone are extruded. If the second orifice is emptied in newly formed bone the tempo-maxillary articulation becomes rigid and ankylosed. But if the sufferer survives for months and years without surgical interference, fragments of necrosed bone can be found in the mouth recalling pieces of coral.

Workers with gingivo-dental lesions are attacked three times as frequently as those with an intact denture (Koelsch). The lesion is also more serious in this case.

Either the inferior or superior maxillary bone, or both, can be affected on one side or on both sides. The course and complications following the necrosis depend on its situation. The lower jaw is attacked more frequently than the upper (60 times as against 40) and the infection is more widespread.

The value of statistics on this point is rather fallacious because they take no account of local and general complications attending the maxillary necrosis. If account were taken only of the data from France and Italy the upper jaw would be found to be attacked in 62.4 per cent. of the cases, the lower in 69.4 per cent., and both together in only 6.3 per cent. in a total of 48 cases.

There are no data as to primary lesions of the bones of the face and nose. When it is a question of the upper jaw the infection spreads sometimes to the orbital plate and even to the base of the brain setting up there a meningitis or encephalitis with neuralgia so violent as sometimes to drive the patient to suicide. The mucous membrane of the palatine vault may hang down so low as to come out of the mouth like a second tongue. If, as sometimes happens, the bone becomes detached, healing takes place, leaving, however, a permanent opening between the mouth and the nasal fossa. At this period the disease is accompanied always by general symptoms — dyspepsia, wasting, sometimes fever, oedema, albuminuria and cachexia. The disease terminates fatally in half of the cases which have run on for an average of two years. Spontaneous cure without surgical intervention takes place in 51 per cent. of the cases of necrosis of the upper jaw and in 57 per cent. of the lower. Other writers give the following figures: 79.5 per cent. of spontaneous cure with total loss of the lower jaw, 10.5 cases of spontaneous cure with partial loss of the lower jaw; in the case of the upper jaw 22.3 per cent. with total loss of bone and 67.7 with partial. Spontaneous cure can take place equally by elimination of the necrosed parts of bones with partial or total regeneration of the bone. Even after healing, however, the necrotic process can break out again in another place if the workman does not withdraw altogether from exposure to absorption. Surgical treatment is said to effect a cure in about 85 per cent. of the cases and certain writers assert that no cure without such surgical treatment can take place. Without it a fatal issue would be the rule in 45 per cent. The first statistics gave lower values (6.4 to 21 per cent.) for the cases resulting in death after operation; the more recent give an average of 17 per cent. for all cases with a slight difference (0.3) in favour of the cases operated upon.

Arnaud in 1897 described conjunctivitis affecting women coming into contact with phosphorous paste in the manufacture of matches. A yellowish tint of the conjunctiva among such workers is often present, but it is unattended by complications. Troubles of sight, which are rare, vary with the susceptibility of the subject. There may be retinal haemorrhage, congestion of the vessels (Niederhausen, 1875), and very small maculae recalling albinuric retinitis. Although there are no precise data optic neuritis cannot be excluded, but such a lesion must be, at any rate, very rare. A case of trigeminal neuritis has been described (Henschen, 1900).

**DIAGNOSIS**

For an early diagnosis of phosphorous poisoning the idea ought not to be persisted in that a substance is not, or only relatively, toxic because other persons exposed to the danger in question show none or very slight signs. In the case of phosphorous poisoning a wrong diagnosis means exposure of the sufferers to a frightful mutilation of the face. Every case of toothache in workpeople handling phosphorus or its products should be watched and the medical man ought to insist on the suspension (temporarily or, if necessary, permanently) of the workman.

The diagnosis is not difficult, especially if the occupation of the sufferer is borne in mind. Examination of the blood is useful in helping to an early diagnosis: any workman suffering from leucopenia, noting especially the poly-morpho-nuclears which do not always stain well; the leucocytes contain droplets of fat sometimes quite large, or a more or less considerable number...
of coloured spots of dark blue when stained with brilliant cresyl blue (Biondi, 1807). With jaundice present a differential diagnosis must be made between the jaundice set up by phosphorus and that due to acute jaundice or to disease of the liver. The digestive disturbances are among the earliest and gravest symptoms. Jaundice and albuminuria, on the other hand, are not so remarkable; multiple haemorrhages occur late and are less grave.

**TREATMENT**

This comes within the province of the medical man; but it is well to remember that of the three methods practised surgically — expectant, resection, and early subperiostial resection — the last named is to be preferred. Discussion, however, is always open. Those who oppose surgical intervention, impressed by the bad results obtained and especially by those of plastic operation, prefer to limit themselves to extirpation of the sequestrum when the necrotic process has completely finished.

**DEMONSTRATION**

*In the air.* — Phosphorescence in the dark is insufficient to decide with certainty that free phosphorus is present, because many other substances yield the same phenomenon. Free phosphorus in the presence of air becomes converted first into phosphoric acid and then into phosphoric acid; but proof of these acids does not suffice to conclude that free phosphorus was present originally in the air in question.

*In man.* — Phosphorus remains a long time in the organs, where it can be detected many months after death. Use is made of the characteristic property of phosphorescence in the dark after having slightly acidified the substance to be analysed. Pedrazzini has proposed the following reaction: Treat the substance to be analysed with sulphuric acid and pure zinc; cause the gas which comes off to bubble through a very weak solution of silver nitrate. Treat the filtrate with ammonium molybdate. In presence of phosphorus a yellow precipitate is obtained soluble in presence of ammonia. If chloride of ammonium is added and a salt of magnesium hastening the formation of the precipitate by rubbing the interior walls of the test tube), a white precipitate of ammonio-magnesium phosphate is obtained.

**PREVENTION**

It should be emphatically stated that, if the dangers of the manufacture and preparation of phosphorus can be limited, they can only with great difficulty be abolished.

So far as white phosphorus is concerned it must be replaced by other substances in the preparation of pastes and powders intended for use as rat, etc., poisons, in the preparation of strips for lighting miners’ lamps, and other articles of commerce.

In addition to measures of prevention common to all dangerous trades, certain special measures should be adopted in certain branches of the industry.

The factory should be remote from houses and built of fire proof materials. Bones should be pulverised in closed apparatus placed in special rooms. The mixture intended to be calcined should be kept in sheds with impermeable floors.

Calcination should not be done, except with bones that have been boiled and dried in closed apparatus of which the joints have been well luted. These operations are generally done in other premises. Further, the apparatus should be placed under a large hood connected to a very high chimney stack and the fumes should be condensed on an intensive plan. The injurious gases would be rendered harmless by ignition. If necessary the duration of the calcination of the bones should be limited to certain hours.

Precautionary measures should be taken at the moment of opening the furnaces. Cylinders, retorts, and condensers must be luted with the greatest care. The gases given off in the course of distillation as well as the condensation and residual water, no matter of what kind, should be collected.

The bone meal should be treated by sulphuric acid and the phosphoric solution obtained concentrated in suitable apparatus. Injurious emanations should be controlled by good locally applied exhaust ventilation. The downward ventilation should be sufficiently powerful and the condensation of the sulphurous gas very intensive.

Washing the product with carbon bisulphide should be done in well-closed apparatus installed in a special room. Distillation should be done in special apparatus having the necessary provision against fire, explosion, and escape of phosphorous fumes. The condensation of these vapours should be as perfect as possible and vigorous inspection of the refrigerating pipes should be organised to avoid obstruction.

Purification should be done in a bain-marie under water pressure; moulding the phosphorus by suction with the mouth should be prohibited.
The phosphorus should be kept under water in a reservoir of cement quite watertight and in boxes submerged in the water.

The acid residuary waters should be completely neutralised before discharge into a drain.

Large open receptacles filled with turpentine should be placed in rooms where phosphorius fumes are given off.

Consumption of food and drink in the workroom should be prohibited; careful washing and dental toilet before leaving work should be enjoined, together with change of clothes, etc.

Medical examination before commencing employment, and periodically afterwards, should be carried out on all persons coming into contact with phosphorus or its compounds or preparations containing it. Workers with dental caries should be suspended and the condition of teeth rectified before again working with phosphorus. The dental inspection, according to Koelsch, ought to be carried out every four weeks.

Statutory regulations have been passed for factories manufacturing phosphorus, especially with a view to the prevention of fire and explosion. To this end fire drill should be strictly organised; dynamos should be isolated (so as to prevent sparks igniting the volatile vapours which can be dispersed in the premises): the current quantity of material should be limited to that actually required; manufactured goods should be removed so as to avoid overcrowding of the workrooms; good daylight illumination or, failing that, incandescent electric lamps should be provided. The electrical installation should be carefully safeguarded and periodically inspected; lamps should be placed outside the windows or enclosed in double and triple envelopes; switches, commutators, etc., should be placed outside the workrooms: the steam heating apparatus should be separated by an adequate distance from the workroom; all hearths should be outside the workrooms and chimneys should be provided with baffle plates or other suitable arrangements to keep back cinders and sparks; smoking and the introduction of boxes of matches or naked lights, etc., in the workrooms should be prohibited; workers should not be allowed to enter them with nail shod boots, etc.

Legislation

The work of manufacturing phosphorus should be closely regulated. Women and young persons should be excluded altogether. While in certain countries the exclusion of women is only limited to the manufacture of white phosphorus, in others it is extended to the use of all phosphorus (Netherlands) and even, as in Japan, everywhere where there is production of dust, vapour and gas, given off from phosphorus or its compounds.

Admission of young persons in these factories is fixed at 15 years in Italy and Japan, at 16 in Belgium, Spain and Greece, at 18 in the Netherlands, and in the States of Maryland, Massachusetts, Ohio and Pennsylvania (unless it can be shown there is no risk), etc.

The periodic medical examination should be made monthly, and special attention should be given to the state of the teeth.

Notification of cases of phosphorius necrosis is obligatory in Austria, Baden, Bavaria, Great Britain, Hungary, the Netherlands (in the chemical industry and in laboratories), Poland, Prussia, Saxony, Switzerland, in the British Dominions (Alberta, South Australia, British Columbia, Manitoba, New Brunswick, Nova Scotia, New South Wales, Ontario, Queensland), in the United States (California, Connecticut, Illinois, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, New York, Ohio, Wisconsin), Yugoslavia, and in Argentina.

Compensation is provided for in the legislation of the following territories: Alberta, Australia: Northern, Western and South; Austria (including agricultural workers), Bolivia, Brazil, British Columbia, Finland, France (manufacture of miners' lamps, toys), Germany, Great Britain, India, Irish Free State, Italy (including fireworks), Japan, Manitoba, Minnesota, New Brunswick, New Hampshire, New Jersey, New York, New Zealand, Norway, Nova Scotia, Ohio, Ontario, Porto Rico, Quebec, Queensland, Rhode Island, Sweden (including manufacture of phosphor bronze and similar substances), Switzerland (including phosphorus chlorides), U.S.S.R., Venezuela, Victoria, Yugoslavia.

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Phosphorus (Amorphous or Red)


Chemistry

Red or amorphous phosphorus, discovered in 1844 by Kopp, and suggested in 1847 by Schroetter of Vienna as a substitute for white phosphorus (in the preparation...
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of the paste for matches), is an allotropic modification of ordinary phosphorus.

Industrially it is obtained by heating white phosphorus to 250° or 300° C., in the absence of air, in closed iron vessels. This transformation can be also obtained below 200° C. if the reaction is carried out in the presence of a little iodine.

Purification is effected after cooling with carbon bisulphide or with a solution of caustic soda to remove any unchanged white phosphorus.

Red phosphorus presents the appearance of an amorphous powder of a reddish brown, red or crimson colour, which oxidises slowly in the air; it is inodorous, insoluble in bisulphide of carbon; its specific gravity is between 2.12 and 2.34.

Heated in the air, it gives off vapour at 100° C.; but does not ignite until 260° C. It is not phosphorescent.

Heated above 260° C. in the absence of air, or in presence of carbon dioxide, it changes again into white phosphorus; heated with lead in sealed tubes, it dissolves in the lead and separates out on cooling in the metallic state (Black phosphorus or Hittford's).

Red phosphorus is considered to be, probably, a solid dissolution of white phosphorus in metallic phosphorus.

USES

It is used especially in the manufacture of matches; in the preparation of the triehloride and iodide of phosphorus and other iodides used in the preparation of organic compounds or of synthetic colours; in the manufacture of incendiary projectiles, etc.

TOXICITY

Already in 1855-1856 Chevalier declared that red phosphorus was non-toxic, and to-day Pouchet considers it to be inert. Jaksch also maintains the same view as in the case of matches made with the sesquiphosphate. Erben considers that any toxicity it may have is due to traces of white phosphorus contained in it, and Robert that it is at any rate infinitely less toxic than white phosphorus. Texevara also in his monograph on matches (1901) concludes that red phosphorus is quite harmless.

If tradition supports the opinion that red phosphorus is harmless, it is not shared by the small number of experts who have studied the substance. Nasse (1885) on injecting 20 centigrams of red phosphorus into the jugular vein of rabbits found they lost their appetite in three days and died in from six to eight days. Post-mortem fatty degeneration of the kidneys, and especially of the liver, was always found.

Filippi (quoted by Giglioli) is said also to have shown some years ago that red phosphorus is not quite innocuous to animals, but that it is at any rate less injurious than white phosphorus. Biondi and Ferrannini (1917) share this opinion. The latter concludes his systematic study of the question by saying that red phosphorus is an enemy less violent and less aggressive to the body than white phosphorus, as it is insoluble and less likely to be absorbed, but that it is not less toxic in itself.

Red phosphorus lessens sensibly the power of resistance of the organism (natural haemolysin, natural haemolytic amboceptor, haemolytic complement, anti-complement, opsonines) even if apparently it does not modify in any striking way the general health. In the blood it acts particularly on the white blood cells, of which it alters the number (first leucocytosis and then leucopenia) and their shape, as well as the red blood cells of which it reduces the number. Further, it reduces the haemoglobin and the coagulability of the blood, increases the cellular resistance and the electrical conductivity of the serum of the blood, stimulates the activity of the myeloid tissue and still more that of the lymphoid tissue (active hyperplasia of the spleen with fatty infiltration and remarkable hyperaemia).

In the liver it sets up degeneration of the cells of the acini, diminishes the quantity of nitrogen and causes the disappearence of the glycogen, but does not modify the amount stored up. In the kidney it brings about the histological changes of acute nephritis and in chronic cases either lesions of acute parenchymatous nephritis or those of interstitial nephritis. It diminishes the adrenal content of the suprarenal capsules, provokes hyperplasia of, and increase of function in, the genital glands of both sexes, causes degenerative changes in the nervous tissue, myocarditis, irritative effects and sometimes ecchymoses and haemorrhagic lesions in the digestive tract and lesions in the bones. Occasionally it induces alopecia and an abundant desquamation of the skin, modifies the respiratory exchange, disturbs the nitrogen exchange, etc.

STATISTICS

Villaret describes the data collected by Ris (1892) according to which troubles terminating in cachexia were said to have been observed in persons handling only red phosphorus in a certain factory. They were, however, due to the chlorates which were ingested through dirty hands rather than to phosphorus.
During the manufacture the workpeople can also be exposed to the inhalation of vapour of phosphoretted hydrogen, and bisulphide of carbon.

Recently it has been stated that in China a certain number of suicides were traced to matches made of red phosphorus and antimony trisulphide, as the probable agent (1923).

**Prophylaxis**

Although laboratory experience proves that red phosphorus is poisonous to animals, this does not mean that it is necessarily toxic to man; and in practice this is the conclusion arrived at. When red phosphorus was first used employers were advised, as a matter of prudence, to adopt in the course of its manufacture the same precautionary measures as in the case of the white variety. The Swiss Regulations of 1882 requiring periodical medical examination in phosphorus match-making were repealed in 1898, except for matches made with sesquisulphide. During later years, no case of poisoning having been notified either to the inspectors of factories or to the Accident Insurance Office, the examination was abolished in all the factories.

It can be concluded, therefore, that red phosphorus does not require the same control as white, and that it can be manipulated with little danger even when precautionary measures are not strictly applied. (See also the articles "Phosphorus", "Phosphorus (Compounds)", and "Matches (Lucifer)".)

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**Phosphorus (Compounds of)**


Among the hydrogen compounds, phosphoretted hydrogen is of the greatest interest here (see that article).

Of the halogen compounds, the most important are the chlorides, which irritate intensely the respiratory tract and the eyes, because, in contact with the moist mucous membrane, they decompose into hydrochloric acid and an oxyacid of phosphorus.

On bringing dry chlorine slightly heated into contact with slightly heated white phosphorus in a retort, the trichloride (PCl₃) is obtained (French: *Trichlorure de phosphore*; German: *Phosphor-Trichlorid*; Italian: *Tricloruro di fosforo*; Spanish: *Tricloruro de fosforo*), which is found mixed with pentachlorides. If a little white phosphorus is introduced, the pentachloride is converted into the trichloride. The trichloride is a colourless liquid with a penetrating smell, fuming in moist air and at ordinary temperatures; it boils at 76° C. In contact with water it splits up readily into phosphoric and hydrochloric acids. In causing chlorine to act on the trichloride, the pentachloride PCl₅ is obtained (French: *Pentachlorure de phosphore*; German: *Phosphor-Chlorid*; Italian: *Pentachloruro di fosforo*; Spanish: *Pentachloruro de fosforo*), which is a solid in the form of small yellowish white crystals. It is the most disagreeable of the three compounds, all of which serve in industry for the introduction of chlorine into organic compounds.

On treating the pentachloride with water or in oxidising the trichloride of phosphorus with chlorate of sodium, the oxychloride POCl₃ is obtained — a colourless liquid, fuming strongly in the air and decomposed by water into phosphoric and hydrochloric acids. In order to lessen the reaction it can be prepared by treating the chlorate by phosphorus oxychloride and then by the trichloride, or again by heating the pentachloride with phosphorus oxychloride of lastly by the distillation of dry oxalic acid.

One case of poisoning by phosphorus oxychloride was reported in France in 1929.

In the preparation of the chlorides of phosphorus apart from the action of the chlorine gas and of the hydrochloric acid, account must be taken of the injurious action of phosphorus and its
PHOSPHORUS (COMPOUNDS)

compounds and to some extent, too, of bisulphide of carbon (solvent of phosphorus) and of carbon monoxide (in the preparation of the oxychloride and of arseniuretted hydrogen).

Butjagin, in Lehmann's Institute, has found that the trichloride has an action on animals analogous to that of hydrochloric acid, but five to ten times as intense as the hydrochloric acid which it forms. It acts mainly by withdrawing from the tissues the water which it requires for its decomposition.

Cases of intoxication have been reported in persons working in chemical laboratories, especially in workmen, where the necessary precautions are not taken.

In literature, we find the cases recorded by Egli (1902); Vaubel (1903), Leymann (1896), Vinassa (in a student), due to the trichloride, and the three cases by Rumpf caused by escape of oxychloride from a broken tube (1906). These three cases were very severe and characterised by acute bronchitis, pneumonia with bloodstained expectoration, cough, air hunger, etc. Another case of tracheal bronchitis was reported at Baden (1913), two cases of conjunctivitis in Switzerland (1917-1918), and lesions of the skin and conjunctiva in Bavaria (1919) in a workman who had unintentionally brought about the decomposition of the compound into phosphoric and hydrochloric acids.

The manufacture of the halogen compounds of phosphorus is carried on in hermetically closed apparatus, which prevents escape of toxic fumes. Application of this system has given the best results in certain German factories.

Transport of halogen compounds of phosphorus should be effected in receptacles of iron, lead, or copper with the lid soldered on, or in glass carboys with ground glass stoppers (paraffined) and covered over by a capsule of parchment paper. The bottles should be packed in boxes stuffed with fossil meal.

Among the oxygen compounds, only phosphoric anhydride is of interest. It is produced by the combustion of phosphorus in a current of air or dry oxygen. It acts as the most energetic dehydrating agent known. It occurs in two modifications: the crystalline (P₂O₅) and the hydrate or orthophosphoric acid (H₃PO₄), which may contain impurities of arsenic, nitric, sulphuric, and hydrochloric acids. It is used as a mordant for the preparation of organic acids, chemical analysis, etc.

The combinations of phosphorus with sulphur are numerous, but it is sufficient here to recall the sesquisulphide or trisulphide (P₃S₃). It melts at 142° C. and is very soluble in bisulphide of carbon. Prepared from red phosphorus as the starting point (because the action of white phosphorus on the sulphur would be too violent) it is used in the manufacture of matches (without phosphorus), of deflagrators, etc. It is regarded as non-toxic. The researches of Bachem (1904, Bonn thesis) and those (unpublished) of Lehmann confirm this view.

Savène and Cahen have administered it by way of the stomach up to 3.5 grm. daily, corresponding to about 6,000 matches, without finding ill effects. A case of necrosis was described, however, in 1919 in an English phosphorus factory, the occupation having been the drying and finishing of the sesquisulphide.

In 1929 Nicolas, Gate and Roussel noted two cases of occupational dermatitis in workers handling phosphorus sesquisulphide in match making. The illness began with lesions on the exposed parts (hands, forearms, conjunctivae) which became general in from twenty-four to forty-eight hours. There was intense erythema of all the integuments with oedema of the face, malleoli, and penis; and then vesicles which soon changed into pustules; and in some places a veritable superficial epidermic necrosis. The patients complained of intense burning sensation and thirst, and shuddering. The lesion then develops; desquamation begins and there is a veritable generalised exfoliating erythrodermia. For several days the patients smell strongly of phosphorus, especially when they are greased. Phosphorus is present in the urine (0.201 grm. per litre in one case). The course of the disease is benign, and there are no symptoms of general intoxication. Conjunctivitis may accompany these lesions or appear separately. The lesions have been induced experimentally in both men and animals. The workers most frequently attacked are those employed in packing the substance.

Cases have also been reported (Swarz, 1929) of dermatitis due to the phosphorus sesquisulphide on the friction strips of match boxes.

The prophylactic measures consist in the elimination of dusts.

Among the phosphides those of lime, of barium, and of strontium should be mentioned. They are used for signals of distress at sea, for safety lamps, etc. Phosphide of calcium is used mainly for the production of phosphoretted hydrogen (see that article); phosphide of zinc in solution (1-5 per cent.) is used for the destruction of rats in
country districts. Being very toxic, it requires every kind of precaution to be taken in both its manufacture and use.

Compounds containing phosphorus and nitrogen are interesting, especially in relation to the manufacture of asphyxiating gases (see this article).

**Legislation**

See the article "Phosphorus".

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**Photo-Engraving**


The invention of photography has led to stupendous progress in the technique of photo-mechanical reproduction. The various methods of engraving formerly followed have all their counterpart in the modern photo-mechanical processes: photo-lithography, collotype, photo-typography or relief engraving usually known as photo-engraving or photo-zincography, process-engraving and hollow heliography.

The German authorities classify the various processes under three heads according as the portion of the plate intended to impart its impress is located above (Hochdruck), on a level with (Flachdruck) or below (Tieffdruck) that part of the surface of the plate which does not receive the ink. The first group comprises, for instance, typographic printing, the second flat printing on stone, zinc, the offset process, photo-lithography, etc., and the third known as "Tieffdruckerfahren" hollow incision, or intaglio printing, also known as heliography and photo-engraving.

The progress realised is due to the discovery that certain substances become soluble after exposure to the action of light. Further, other substances — resins — are found to resist the etching action exerted on metals by mineral acids. These resinous substances have therefore been used to coat designs traced on or applied to stone or zinc or copper plates so that the acid may etch the non-protected parts of the surface and give the required relief.

For perfect technical reproduction, an original must possess certain qualities. It is because of this that the resources of photography (orthochromatisation, special lighting, time of exposure, etc.) and especially retouching are called in to correct the defects of the original and prepare it for reproduction by photo-engraving.

Retouching is at present effected by an aerograph spray worked by compressed air which projects the coloured solution in powdered form on to the photograph to be retouched.

Photographic reproduction of the original also demands special technique involving the most up-to-date photographic apparatus and methods (lenses, lighting, plates, etc.).

The plate used in photo-engraving must necessarily be freshly finished, that is to say, prepared as required for the work in question. The sensitised surface consists of collodion or special emulsion. As a rule, albumen is used or a bichromate collodion.

Photo-lithography is little used. Photo-typography is now widely used for the printing of illustrated postcards.

Below are some particulars of photo-engraving, which is the most commonly employed process.

In this process and in that used for the reproduction of pictures in half-tones, the model is represented by combinations of points and lines more or less thick and more or less spaced. The success of this principle has been demonstrated by typographic photo-engraving or American process-engraving with the use of lined screens of glass. The presence of the screen in front of the sensitised plate results in the transformation of the continuous lines and variable opacity of the image into broken lines formed exclusively of dots of similar opacity but of unequal dimensions, the more or less spaced arrangement of which provides a sensation of shading reproducing exactly the values of the original image.

The screen used varies according to the object in view (commercial work, artistic work, etc.), the paper to be used in printing, etc. The plate, after preparation and utilisation for reproduction, is developed, fixed, reinforced and dried.

Then follows preparation of the film bearing the reproduction. Layers of para rubber and collodion are spread over it to give it resistance in the course of later manipulation, and it is detached from its glass support. It is then placed on the metallic block (zinc or copper), which has first been rendered sensitive to light.

As in all processes of graphic reproduction, this layer is rendered sensitive to light by means of double
salts of chromium (bichromates) in the presence of an organic substance (albumen, gelatine, fish glue, gum, etc.). The colloid thus formed and dried is subjected to the action of natural or, more frequently, artificial light. The transparent parts of the negative allow the light to arrive on the sensitised layer and in the parts thus illuminated the colloid undergoes reduction of the bichromate, which is converted into a black compound of chromic oxide. The latter loses the property peculiar to the bichromate of being soluble in water. Hence, in accordance with varying intensity of the negative, the bichromated colloid will become more or less soluble to the extent to which the various parts of it have or have not been affected by light.

For line-etching, a layer of ink is spread with a roller, which is passed over the surface and the parts of the emulsion corresponding to blanks in the picture made soluble by light are removed. For reticulated or coloured etching, the design is inked with methyl violet, and the film is heated to turn the glue into a substance which will withstand the etching bath (enamel). In a plate containing line etching, however, inking does not suffice to protect the incision sufficiently against the action of the acid bath. For this reason the surface is dusted with resinous substances (bitumen, pitch, colophan or "dragon's blood"), which melt under heat and intimately mix with the ink.

A coating of varnish is thereafter applied to the back and sides of the plate, which is passed through an etching bath or sometimes under a spray of acid solution.

Parts which do not require any further exposure in the bath are retouched with fatty inks, and such retouching and exposure are repeated as often as necessary until the results desired are obtained. The action of the acid is sometimes replaced by the use of a milling tool, whilst small defects of mechanical and chemical incision are corrected with a burin.

When copper replaces zinc, the etching bath consists of chloride of iron rather than nitric acid.

The plate is finally mounted on a block of wood or lead.

For the etching bath, nitric acid in a 10-12 to 25 per cent. solution at 15-40° B. is used, varying according to the country and the type of engraving. For deeper engraving, sulphuric acid at 15-20 per cent. is used. To this is added sometimes hydrochloric acid, nitrate of ammonium, ammonium chloride or acetic acid. A solution of ferric chloride or nitrate of potassium, hydrochloric acid and alum with an average strength of 16° B. is also used.

The vats may be made of tarred wood, earthenware or stone. In the workshop they are generally provided with a wooden cover. Three types of etching baths are in use for engraving in Great Britain: (1) the "Levy" bath, in which compressed air driven through fine nozzles into an acid bath causes fumes to rise which impinge on the zinc plate placed on a shelf above the bath; this operation is carried out in a closed apparatus provided with a device for drawing off the acid fumes; (2) the "Mark Smith" bath, which is a closed receptacle in which the nitric acid passes through holes in the bucket of a rotary paddle which sprays it on to the plate to be engraved (splash type of etching machine); this receptacle is covered with an aluminium lid which, when not fitted tightly, may allow some of the acid fumes to escape; in large establishments a double bath is used; the amount of the fumes escaping into the workroom cannot be very great; they tend rather to keep down in the bath; (3) "rocking tubs", usually automatic, are now used mainly as finishing baths, and the percentage of acid in these is lower than in the other two; elimination of fumes is effected by general ventilation, improved in certain cases by mechanical devices. Where the intaglio process is used, engraving is done on large copper cylinders and the etching material has a ferric-chloride basis so that no dangerous fumes arise. There are now highly improved engraving machines provided with ventilating devices for exhaust and elimination of acid fumes, and these new systems render the use of strong acids unnecessary.

Corrosion in the etching baths depends on the layers of ink and resin previously applied to the plate, and on the depth of the cavities and the clearness of the impression which it is desired to obtain. For reticulated incision the enamel suffices for protecting the black parts and the plate is passed into the etching bath without requiring inking or the application of layers of resin.

After the acid bath the plate is washed, dried and printed with printing ink as a means of controlling the incision.

In a new process called in Germany Tieferdruckverfahren (intaglio, roto-engraving, heliography) the etching is not in relief, but in intaglio.
Copies are printed by filling the hollow parts of the etching with ink and then applying the paper by means of a press. This process is very much used at present especially for the printing of illustrated periodicals, and the plate may then be adapted to rotary cylinders.

A negative plate of the subject is first printed and then a positive plate, which is photographed by artificial light on a paper with a gelatine pigment which shortly before its use is sensitised by being passed through a bath of bi-chromate of 3-5 per cent. During the printing operation a very fine network effect, which is acid proof, is imparted by the use of a screen. The paper applied to the prepared copper plate is developed in hot water, which dissolves the bi-chromated gelatine in those parts which have not been acted on by light, and causes a more or less extensive loss of colloid in the other parts in proportion to the amount of light to which they have been subjected. There follows washing in cold water, drying, and a final bath of hot water for elimination of the paper. In the etching bath which has a basis of perchloride of iron in a concentrated state or in an accurately calculated solution, the parts of the plate are acted on by the acid in proportion to the thickness of the gelatine layer. The hollows of the plate are thus more or less deep and form intaglios which serve to retain the ink. The operations of inking and wiping are effected by mechanical devices. A roller which rubs over the surface removes any excess of ink.

The bi-chromated coating is applied by hand — the liquid mass is poured on to the plate and spread uniformly by means of a pad or by machinery which not only spreads the mass but also dries the plate.

According to circumstances, the developing bath may be alcohol, glycerine, acetic acid, citric acid, glycol or calcium (a concentrated solution of chlorate of lime), etc.

In helio-typography, or photo-typography, use is made of the property of gelatine of holding ink on the dry parts but not on the wet; and of not holding water on parts made insoluble by light and vice versa. A bi-chromated gelatine in this process is applied to a large crystal plate and the copies are printed directly on to the gelatine coating.

In reproduction by three-colour printing the direct process is now used which does away with screens and positive plates, the whole process being reduced to one single operation, which provides at the same time the colour selection and the corresponding negative already stopped out.

The collodion emulsion containing bromide of silver specially coloured for each reproduction enables the plate to be sensitised only for certain rays. There are naturally simpler and easier colour reproduction processes which need not be dwelt upon here.

Galvanotyping and stereotyping involve only reproduction or duplication of existing plates.

Galvanotyping is effected by taking a hollow wax imprint or a negative of the original plate and passing it through an electrolytic copper bath, having previously rendered the imprint a good conductor by the application of graphite. The electrolytic process deposits the metal in a layer on the matrix and it thus gives a positive reproduction of all details recorded on the wax imprint. On removal from the bath the positive reproduction is retouched and the layer of copper is rendered more resistant by mounting it on an underlying layer of lead. It is there after usually mounted on a block.

In stereotyping the imprint is obtained by means of a powder or a special kind of cardboard (utilised as matrix for direct fusion of the positive reproduction) and a mixture of lead and antimony (see article "Printing Trades").

In the "pantone" process invented in Great Britain silvered plates are used for printing and these are cleaned by means of a powder with a mercury base. Similarly, a paste with this base for the printing off of copies. Experiments by Koelsch show that the surrounding temperature suffices to cause the very fine layers of mercury remaining on the plates to liberate fumes in sufficient quantity to represent a danger to the workers' health.

The technical advantages of this process assure it of a great future but it is essential that from now onwards efforts should be made to ensure the provision of good localised ventilation over the machines and the adoption of adequate general precautions (periodical examination, personal hygiene, in particular of the mouth, effective methods for detecting mercury in the air of the workrooms, etc.).

Hardly any type of artificial light other than electric arc lighting is now used, the carbons utilised being specially prepared. Mercury vapour lamps have completely disappeared.
PHOTO-ENGRAVING

SOURCES OF RISK

As regards causes of injury, account must be taken of the chemical products employed by photo-engravers: mineral and organic acids, methyl alcohol, ammonium-hydroxide and -chloride, aniline, benzene, benzine, chrome acid and bi-chromate, bromides of copper, of cadmium, alkalis (ammonia, carbonate of soda and of potassium, and caustic soda), phenic acid, chloroform, chloride of silver, chrome alum, cyanide of potassium, sulphuric ether, formaldehyde, potassium iodide, mercury bi-chloride, mercury, ammonium sulphide, collodion coated with verdigris, etc. (E. J. Volz). The principal danger to which photo-engravers are exposed arises from the liberation of small quantities of acid fumes (nitrous or sulphuric) when photogravure is effected in open or inadequately covered vats. An analysis made in Italy in order to determine the quantity of nitrous fumes liberated at a surrounding temperature of 16° C. by nitric acid (using the method of absorption by calcium) has provided the following figures:

<table>
<thead>
<tr>
<th>Percentage of pure nitric acid</th>
<th>Percentage of nitric acid at 20° B.</th>
<th>Quantity of nitric oxide in mg. per litre of the total solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>9.4</td>
<td>80</td>
</tr>
<tr>
<td>9.0</td>
<td>17.0</td>
<td>130</td>
</tr>
<tr>
<td>10.0</td>
<td>18.9</td>
<td>140</td>
</tr>
<tr>
<td>12.0</td>
<td>22.6</td>
<td>150</td>
</tr>
<tr>
<td>14.0</td>
<td>36.4</td>
<td>500</td>
</tr>
<tr>
<td>15.0</td>
<td>28.3</td>
<td>250</td>
</tr>
<tr>
<td>14.0</td>
<td>28.3</td>
<td>250</td>
</tr>
<tr>
<td>16.0</td>
<td>30.9</td>
<td>450</td>
</tr>
<tr>
<td>18.0</td>
<td>36.0</td>
<td>800</td>
</tr>
<tr>
<td>20.0</td>
<td>37.7</td>
<td>1,300</td>
</tr>
<tr>
<td>21.0</td>
<td>40.8</td>
<td>1,500</td>
</tr>
<tr>
<td>23.4</td>
<td>44.1</td>
<td>2,500</td>
</tr>
<tr>
<td>25.0</td>
<td>47.2</td>
<td>4,000</td>
</tr>
</tbody>
</table>

Approximate figures.

Hence a weak solution of nitric acid only liberates a small quantity of nitric oxide, which is immediately transformed into nitric di-oxide when in contact with air. This liberation increases in direct proportion to the increase in the acid content.

According to the interesting and detailed report of Engelhardt and Mayer (1931) on cases of eczema due to chromates in the printing industry (photomechanical reproduction), workers are exposed to injuries to the skin in consequence of contact with these products in the course of preparation of the mother liquors and dilutions of bi-chromates; in the course of rubbing by hand with a pad, of transport of the sensitised layers, of sensitisation of the paper-pigment, of development and various washing operations of the bi-chromated surface (the bi-chromate being present in the water) of the etching bath, and during printing.

Photo-engravers are further exposed to the harmful action of luminous rays emitted by unprotected lamps, notably those rich in ultra-violet and infra-red radiations, as well as to that of dust from the products employed (graphite, pitch, tar, "dragon's blood") chiefly during grinding; also to the harmful effects of benzol, xyloc, toluol, and toxic gases from the drying stoves, etc. They are likewise exposed to excessive heat produced by the rheostats, to fragments and turnings projected by filing machines and lathes, etc.

STATISTICS

Statistical data concerning this group of workers are relatively scarce. According to information furnished by the German Union of Lithographers and Allied Workers, whose membership comprises 98 per cent. of the German photo-engravers, the number of deaths for the period 1919-1921 was 63, with an average age of 39°/2 years, and an average duration of sickness of about twenty-five weeks. Amongst the causes of death, respiratory diseases appeared 22 times, cardiac diseases 12, gastro-intestinal troubles and kidney trouble 10, and suicide and accidents 9 times.

According to information furnished by the Berlin Sickness Fund for Lithographers, 76 photo-engravers were incapacitated for their work during the year 1922 by influenza, colds (28 cases), respiratory diseases (12), rheumatic affections (6), internal diseases (8), nervous diseases (6), eye trouble (5), affections of the external organs or accidents (19).

For the period 1906-1921, the total number of deaths amongst German photo-engravers was 245, the average age at death was 34 years and 9 months in 1906-1910, 37 years in 1911-1915, 39 years in 1916-1920 and 39°/2 years in 1921. The causes of death were as follows: tuberculosis (92), respiratory diseases (9), heart diseases (32), diseases of the peripheral nervous system (4), of the central nervous system (25), of the stomach, intestines and kidneys (30), miscellaneous diseases (23), suicide and accidents (30).

An enquiry effected by Engelhardt and Mayer covered 114 workers engaged in photomechanical reproduction; 19 suffered from eczema due to chromates, 11 had previously suffered from it, 84 showed no eczema — thus there was eczema due to chromates in 26 per cent. of the workers examined. Of the 114 workers affected, 24 (80 per cent.) showed positive reaction to the test (bi-chromates).

In the United States an enquiry undertaken in 1926 amongst photo-engravers in
New York revealed the fact that 64 per cent. suffered from throat trouble. A comparison of the mortality rate due to various causes in this industry, and of the incidence of pulmonary diseases, revealed a high incidence of such diseases.

In Great Britain it was reported that generally speaking, members of the Amalgamated Society of Lithographic Artists, Designers and Engravers are particularly liable to complaints of the respiratory system, and that probably line-etchers would be more susceptible than workers in other branches. In 1929 Overton visited thirty-one workshops and examined about 150 workers engaged in photo-lithography. She found that 7 per cent. of the workers suffered from dermatitis, more particularly those engaged in transfer work, in photo-lithography and in the printing of proofs. She attributes the causes of these lesions to chronic acid, salts of chromium and turpentine.

In Italy Sinapi undertook an investigation in 1924 among 15 workers belonging to three different zincographic establishments, and noted 17 cases of diseases of the digestive system (113.8 per cent.) distributed as follows: stomatitis (4), Burton line (2), decayed teeth (8), constipation (2), intestinal colic (1). Sinapi considers that these cases represented chronic poisoning by zinc. As regards the respiratory system, 13.3 per cent. of the cases were bronchial catarrh. Finally, he reports an occasional stigma consisting of a callus situated on the radial side of the third phalanx of the right index finger. This stigma would appear to be due to manipulation of the burin, since the two workers had been previously engaged in wood sculpture.

Biancalani in 1931 met with several cases of eczema, due to chromates, amongst photo-engravers in Florence.

**Pathology**

The work of photo-engraving does not of necessity set up a specific disease in all cases, but it has been noted that in the long run the general system becomes affected. In the Manchester district workers who had carried on this trade for about fourteen years were usually pallid, though it was not possible to detect symptoms of poisoning. Certain of these workers complained of a constriction of the chest, or irritation of the throat accompanied by fits of coughing, especially when they were engaged on etching a plate of large dimensions. It would appear that these symptoms occurred during the use of open rocking baths and were not present when "Levy" and "Mark Smith" baths were used. The introduction of these types of baths in England appears to have considerably improved working conditions amongst photo-engravers.

It has been observed that acute or fatal diseases might occur in consequence of the inhalation of the products liberated from etching baths, which would seem to indicate the possibility of poisoning by arseniuretted hydrogen (toxic jaundice). In this connection several samples of zinc were analysed for arsenic and lead in the chemical laboratory of the Labour Inspection Department of the Netherlands, but the results were negative. The possibility of the acid fumes liberated during etching exercising a harmful action, and even giving the clinical picture of acute poisoning due to nitrous fumes, cannot, however, be excluded. A case of this kind was encountered in the Netherlands in a photo-engraving shop where the manager had an attack of pneumonia, following on the inhalation of these fumes. In the case in question, the liberation of these fumes was, however, the fault of the worker who had thrown sawdust on concentrated nitric acid which had escaped from a broken flask.

The harmful effect of acid fumes on the teeth has been confirmed on various occasions.

Stoke reports a case of acute poisoning by xylo1 and toluol in intaglio printing, and Koelsch reports cases of mercury poisoning caused by the "Pantone" process.

It is not necessary to deal in detail with the skin lesions which may be encountered amongst photo-engravers, and to which reference has already been made. Pankhurst in 1925 noted cutaneous lesions amongst workers engaged on the cyanographic process. Casazza in 1928 noted a case of acute eczema affecting the hands of a phototypist, accompanied by rhagades and progressive alteration of the nails. Tests for skin reaction to the numerous products handled point to bichromate as the sensitising substance. Fellow-workers of the patient also suffered from cutaneous injuries, due to bichromates.

**Hygiene**

Special importance must be accorded to the ventilation of the workrooms. It is hardly necessary to insist on the importance of cleanliness and good lighting.

Photo-engraving, and in particular etching — especially in the presence of strong acid solutions — should be carried out in an adequately ventilated workroom. The baths should be provided with exhaust hoods for removal of irritant fumes outside the premises.
It is very desirable that mechanical manipulation should increasingly replace work done by hand. All adequate protection should be afforded to avoid the projection of acid droplets and splashings. It is advisable that the operation of applying resinous substances should be effected in a special workroom set apart for this purpose. This provision of exhaust withdrawal of metallic dust is essential during milling, where such operation is necessary and during the polishing of the cylinders used in roto-engraving.

Carboys containing concentrated nitric acid, should be encased in straw and kept outside, or in a cellar. Similar measures should be taken for the storage of all dangerous materials used especially liquids.

Artificial light should be installed in such a manner that dangerous radiations are filtered and adequate protection of the eyes is afforded when necessary against injury from powerful sources of light.

Adequate personal hygiene should be enforced for all workers engaged.

Protection of the hands and the exposed skin in general from the irritant or caustic action of substances manipulated is essential; in certain cases a periodical medical examination is to be recommended.

Finally, the attention of workers should be drawn to the risks which they incur, and more especially, as occasion arises, to the dangers connected with nitrous fumes, chromates, toluol, xylol, mercury, etc.

**LEGISLATION**

No special provision exists relative to this category of worker. Skin diseases, as well as certain forms of poisoning are frequently covered by the general formulae adopted in laws on compensation. Optic neuritis and retinitis, as well as ulceration of the cornea, and conjunctivae occurring amongst photo-engravers, are subject to compulsory notification in the Netherlands.

**BIBLIOGRAPHY**


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**Photographic Industry**


**TECHNICAL DATA**

**Photographic Plates and Papers**

The photographic industry receives from glassworks glass of a quality corresponding exactly to the purpose for which it is intended, in the form of plates of a size which is generally a multiple of that of the product which is to be manufactured. The glass plates are carefully examined as regards thickness and the absence of defects, cleaned in an aqueous solution of boiling soda and covered while still in the wet state with a very thin layer of a dilute solution of potassium or sodium silicate or of chrome alum, the purpose of which is to facilitate adhesion of the layer of gelatine. This solution is poured from a receptacle through a layer of material (apron) stretched over the plate which passes underneath. The plates then pass to a drying trough and are ready to be covered with a photo-sensitive gelatine. Meanwhile, they are sorted out in order of size and placed on shelves which must be dust free.

Preparation of the sensitised emulsion involves very careful manipulation and demands long experience. The very pure quality of gelatine used is subjected to sorting, careful washing in water and thereafter in an alkaline solution. An aqueous 6-7 per cent. solution of gelatine is treated in a water bath with a slight excess of potassium bromide and a nitrate of silver. The chemical reaction which takes place in the solution differs to a great extent from the similar reaction in an aqueous solution since the presence of a compound albuminoid substance of varying composition exerts a chemical action on the grains of bromide of silver both at the moment of reaction and later during what is called "maturation". The length of time required for digestion, subsequent thermic treatment or maturation depends on the increase of the photo-
sensitivity as well as on the point of sensitivity, the gradation and other physical constants. The reaction terminated, the emulsion is poured into nickel capsules and caused to cool gradually from the temperature of the solution down to about $-2^\circ$ C. The gelatine congeals and is then passed through a filter press and then washed in filtered and distilled water at $10^\circ$ C. and thereafter in alcohol in order to eliminate the nitrate of silver.

The emulsion is then treated with a view to freeing of silver. The film obtained is cut out into cubes which are then washed in filtered and distilled water at $10^\circ$ C. and thereafter in alcohol in order to eliminate the nitrate of silver. The emulsion is then treated with a view to freeing it from any chemical impurity. It is filtered under pressure through parchment and then through a cloth filter and through cellulose. An antiseptic mixture is added in order to ensure conservation and the product is kept in freezing chambers at about $-2^\circ$ C. Before use the emulsion has to be carefully examined in the laboratory.

In all workshops which have to serve as dark rooms lighting is only provided by a few red lamps strictly tested by a spectroscope. In all workshops which have to serve as dark rooms lighting is only provided by a few red lamps strictly tested by a spectroscope.

For the application of the emulsion to the plates the sensitive gelatine is melted at $30-35^\circ$ C. and spread on to the plates by machinery. Whilst washed, dried and prepared plates pass along the conveyer under the machine, the emulsion contained in the vat is spread over the whole surface and on one side in a perfectly uniform manner. The plates are then removed on moving frames, washed on the glass side in hot water and thereafter led to an ice-cooled bench. After passing through a drying trough the plates receive a final drying and are then cut into the desired sizes. The plates, after cutting, are removed on a conveyer under the examining room, where women workers examine them with a view to finding out defective cutting or faults in the sensitive layer. The plates, after revision, are wrapped in black paper and placed in cardboard boxes. They then leave the dark room and arrive in the packing department where packing and labelling is effected mechanically.

In all workshops where prepared or emulsified plates are present there must be absolute freedom from dust, gaseous products and as far as possible from microbes. Adequate plant for air purification is indispensable. The air passes over layers of pumice stone impregnated with a special liquid calculated to absorb the carbon dioxide, sulphuric acid and other gaseous impurities. It is then heated, passed through a cloth filter and sent into the workrooms with provision for avoidance of draughts likely to cause discomfort. Further, the air must have a constant temperature and humidity rate.

When films made of celluloid or acetylc cellulose are used in place of glass plates the application of the emulsion is similar to that used for papers. The same care is taken of the operations of drying, winding and cutting out. Nevertheless, prior to the application of the sensitised emulsion the surface requires to be prepared with a view to facilitating application and adhesion. For this purpose the surface of the film which is to be covered is dipped in a solution of celluloid. Recently, a proposal was made to use furfurol in this connection. This process resembles the "floation" process used in spreading photographic papers.

In the preparation of printing papers it is very rarely, and only under quite special circumstances, that such papers are intended for negative proofs. Mention will therefore only be made of papers intended for positive proofs. The paper furnished by fine-paper factories (stored, first of all, in well-ventilated workrooms where the temperature is carefully controlled) is subjected to preliminary preparation by means of earthy alkaline sulphates with a view to covering with a very thin layer any small defects in the paper and furnishing a pure white or slightly tinted background for the later application of the emulsion. In general, baryta is used; an extremely fine suspension, filtered several times, of barium sulphate chemically pure and to which a small amount of gelatine, a little colouring matter and certain chemical substances facilitating conservation have been added. The band of paper then reaches the drying room, where it is stretched over an endless belt and passes through several calenders, which gives to the baryta paper a good glazed surface. The later operations are only effected in workrooms lit artificially by red light, the temperature and humidity rate of which are strictly controlled. The preparation of the chloride or bromide of silver emulsion is in general similar to that for photographic plates, but it may be prepared with gelatine, albumen or collodion, etc., according to the type of sensitive paper required. The collodion solvents (ether, alcohol) are withdrawn by exhaust ventilation and recovered either for economic reasons or with a view to avoiding the risk of fire. The spreading of the paper is effected in the same manner as that followed in the case of plates.
The emulsion liquefied by heat is contained in a silvered receptacle placed above the machine. A tube attached to the base of this receptacle terminates in a horizontal silver tube, the length of which corresponds to the width of the paper to be spread and which is perforated throughout the whole of its length. The method of "flotation" of lengths of paper over a bath of emulsion at a constant level is also utilised. The paper after receiving the layer of emulsion arrives in the drying room where it is again wound on to a roll.

According to requirements, the paper is sent on to the cutting rooms or to machines which cut it into various sizes and count these automatically. The sheets, after careful sorting with a view to elimination of defective samples, are enveloped in red paper which is damp-resistant, and thereafter in black paper or envelopes. They may then leave the dark rooms and reach the final process of packing.

A brief reference suffices in regard to colour photography. This latter process has been so far obtained by colour selection on different plates, rendering impossible, however, photography of moving subjects. The discovery of the single autochrome plate certainly constitutes progress since it reduces the operations to one single process, but posing has to be longer than in the case of snapshots. Now, thanks to the English Finlay process, it is possible to take snapshots at 1/50-1/100 second in colour.

**Pathology**

It is known that gelatine serves as a favourable culture medium for the development of most types of microbes. It is further a very sensitive albuminoid substance. The whole series of operations constituted by the preparation of photographic plates and papers requires a constant temperature and humidity rate in the workrooms and an exceedingly pure atmosphere. In other words, the working conditions in the photographic industry are favourable to the health of the workers employed. It must, however, be added that as a result of the more extensive application of machinery in this industry the number of workers employed has been greatly reduced. It is only in course of preparation of films that there still exists a certain risk connected with the use of celluloid solvents.

Doctors have, however, for long stressed the detrimental effect on health of permanent work carried on in dark rooms necessitated by the photo-sensitive quality of the products used. Agasse-Lafont and Heim de Balsac found amongst 84 per cent. of photographic workers a slight degree of mononucleosis (40-45 per cent.), which they were inclined to attribute to manipulation of salts of silver, and similarly a slight degree of eosinophilia, which they attributed to the action of amylacetate and acetone fumes. L. Carozzi (1913), as the result of a series of examinations effected amongst workers in a photographic plate factory in Milan, was able to confirm the presence of mononucleosis and eosinophilia, though he found no marked diminution in the haemoglobin or in the number of red blood cells and leucocytes. Carozzi considers that the slight changes in the blood are merely the sign of oligochromia, which is common amongst workers; further, that the absence of daylight might be considered as practically harmless and that the air of the workrooms was likewise free from any serious objection as regards health.

Elizabeth Kruger (1924) has resumed this study and examined working women employed in dark rooms. She was not able to find any specific general symptoms and in particular no diminution of the haemoglobin. For this reason, Gerbis has sought the explanation of the poor health frequently found amongst these workers in the defective composition of the air, the absence of ventilation and the effect of certain products, namely, sulphuretted hydrogen, rather than by the absence of daylight.

Gerbis has often received complaints from small reproduction workrooms relative to the work effected in dark rooms. As far as spacious workrooms in modern plant for the manufacture of photographic plates, papers and films are concerned, the state of health of the staff — to a large extent women workers — is quite satisfactory, and the morbidity figure is usually low. It should, however, be remembered that the effect exercised by permanent work in a dark room on those unaccustomed to it may lead to a state of anxiety and nervous excitement which may, where complicating circumstances occur, even lead to panic. Amongst individuals with weak nervous systems the nervous tension resulting from permanent work in dark rooms is continuous and may even lead to states of depression with a sensation of pressure resembling constriction by a tight helmet (Gerbis).

Dr. H. Gerbis
(Berlin).
Photographers

It is scarcely possible to end this article without brief mention of the pathology of photographers called upon to handle and use photographic products (plates, films, papers, etc.).

It is chiefly developers which are responsible for a number of skin diseases, generally localised on the hands. Amongst predisposed individuals these may sometimes even attack other parts of the body.

Amongst developers the aminophenols (see that article) are those which present the greatest interest from the medical point of view. In 1898, Freund drew attention for the first time to the acetone solution of metol (sulphate and monoamethyl-para-amino-phenol), in 1925 W. Ermen announced that a kind of metol without a poisonous effect on the skin had been discovered, but despite this several cases were reported later.

Metol causes an erythematosus and eczematous form of cutaneous disease. The former, described by Freund, Krébich, and St. Weidenfeld, is localised principally on the fingers and hands and may cause a condition which is comparable to that of local asphyxia.

Stors has noted in one case symptoms of a general order: fever, weakness, irritation, etc., whilst the cutaneous manifestations also attacked the extremities. The nails are often affected.

The eczematous form similar to that caused by turpentine, etc., may be very serious, especially when in the case of a relapse the eczema becomes infected and spreads all over the body.

In a case studied by Freund the patient was a young girl who dipped her fingers in a solution containing borax, gold chloride, chloroplatinum, citric acid, hyposulphite of soda and ammonium sulphate. The skin disease attacked her face.

An enquiry carried out by Karasek (1911) in Chicago workrooms revealed 31 cases of dermatitis and ulceration due to metol.

Beers reported cases of dermatitis and eczema in 1908; Knowles (1913), 4 cases amongst photographers; and Hamilton (1921) one case affecting a photographer who suffered from dermatitis and eczema during the nine years in which he worked with metol.

In his report for 1929 the British Chief Medical Inspector of Factories records that, according to an investigation made amongst photographers, cases of dermatitis due to hypo acid in a solid form were encountered. On the other hand, cutaneous troubles due to metol might be, it is stated, avoided by washing off immediately any splashings of the developer with a weak solution of mineral acid. It is essential that no soap containing free alcalis should be used.

Pyrogallic acid colours the hands and nails dark yellow and even black; para-phenylenediamine ("Metacarbol") gave rise to the following symptoms in the case of a photographer: diarrhoea, vomiting and vertigo; quinone-dichlor-diamine to difficult to remove, of the skin; amidol (diaminophenol) and rodinal (potassic phenolate of para-midophenol) to eczema; handling of platinum printing paper has caused (according to the enquiry quoted by Karasek dealing with 40 Chicago workshops) 8 cases of poisoning characterised by violent irritation of the throat and nose, sneezing, coughing, bronchial irritation, respiratory troubles, eczema, etc.

The carbon or colour process has caused cutaneous troubles attributed to chromates (Burns, Edinburgh, 1904) and which Richardson, of London, designates "the bichromate disease".

Silver nitrate causes a form of disease known under the designation of argyria (see article "Silver"), typified by a blackish coloration running to deep black of the skin which is extremely difficult to remove, in the case studied by A. Reuss (1887) affected a photographer who showed also black coloration of the caruncula lacrimalis and part of the bulbar conjunctiva.

Account must likewise be taken of the harmful action of the skin and mucous membranes of other products handled by photographers: nitric, hydrochloric, and oxalic acids; chromates, especially in the colour processes, helio engraving and photo lithography (see article "Photo-Engravers"); mercury bichloride — often in 2-5 per cent. solution — cyanide of potassium — in a 2-10 per cent. solution — which causes serious dermatitis amongst workers engaged in galvanoplastie processes and photographic reproduction (collodion process); iron chloride; caustic soda; alcalis in general; nitrate of uranium; aurantia; solvents; salts of bromide and salts of iodine; etc.

A further cause of injury is related to the long hours spent in the dark room, which is often badly ventilated and in which the atmosphere is vitiated and which presents conditions of damp heat.

Retouchers have been found to suffer from syphilis and tuberculosis transmitted by the common use of brushes.
A bad habit which has given rise to infection is that of pointing the brush by placing it between the lips (Freund). This bad habit obviously represents a possible source of numerous types of poisoning.

It is necessary in conclusion to recall the use of very powerful lighting sources for reproduction work and their detrimental effect on the eyes. Duke Elder has reported cases of iritis amongst photographers due to exposure of the eyes to the action of sources rich in ultra-violet rays.

HYGIENE

It is not possible to suggest any special hygienic measures in the photographic plate and printing paper industry. On the other hand, the measures indicated in the article "Chemical Trades" should be recommended for adoption in the case of photographers as likewise those referred to in articles dealing with the various products manipulated by photographers.

LEGISLATION

Skin diseases (eczema, dermatitis) amongst photographers and likewise mercury poisoning are subject to compulsory notification in the Netherlands; forms of dermatitis due to chemical products receive compensation in Bulgaria, and mercury poisoning in Sweden. See also article "Occupational Diseases: Definition and Compensation".

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Picric Acid

(Trinitrophenol, Trinitrophenic Acid)


CHEMICAL PROPERTIES

Pure picric acid C₆H₅(NO₃)₃·OH is in the form of rectangular foliate, elongated crystals, varying in colour from lemon yellow to reddish yellow according to the manner of production, odourless and with a very bitter taste. These crystals melt at 192.5° C., are slightly soluble in cold water, more readily soluble in hot water, ether, alcohol and especially in commercial petroleum spirit.

Picric acid, which is a powerful colouring agent, is a strong acid; it decomposes carbonates and even nitrates and chlorates in the presence of moisture.

It was first mentioned by Hausmann (1788) as arising from the action of nitric acid on indigo, and Welter obtained it later by reaction of the same acid on silk, while Laurent prepared it from phenic acid without it. It was first used industrially by a silk dyer at Lyons.

In commerce a less pure (sulphonated) variety is known. In compressed form or in a fused state it is explosive and must be handled, packed and transported subject to the rules for explosives.

Picric acid [C₆H₅(NO₃)₃·NH₂·OH], which is got by reduction from picric acid, has red crystalline needles melting at 168-196° C. It is used as a colouring agent, chiefly with picrate of ammonia, giving a deep red colour. It is also used in photography.

Picrates are metallic salts yellow in colour with a bitter taste generally insoluble or slightly soluble in water, alcohol, ether, except the potassium salt which is very soluble and easily crystallised. These salts are more highly explosive than picric acid itself. The picrates of calcium and sodium catch fire by simple friction. They are chiefly used in combination with other chemicals such as ammonia and potassium.

INDUSTRIAL OPERATIONS—USES

Picric acid is prepared from phenol. 100 parts of phenol are mixed with 500 parts of sulphuric acid and the mixture kept at 100° C. for about an hour. The sulpho-phenol thus obtained is poured on to a mixture of nitric acid and nitrate of soda at 28° Bé. Sulphonation is usually carried out in cast iron receptacles and the nitration in stoneware vessels or brick-lined cast-iron basins. They are mostly provided with covers, each having a chimney leading to condensation and recuperation chambers. Great heat accompanies the reaction and nitric acid fumes are liberated. The temperature in the nitration vessels must be kept above 110° C. for a fairly long time, after which it is allowed to drop, the mixture being then diluted with water. It is left for 24 hours, then the mother liquors are decanted and the picric acid recovered and poured into double-bottomed tubs and washed with water. It is subsequently heated and dried at about 50° C. and put through a sieve.

Picric acid has been, and still is to a reduced extent, used in the dye industry in the preparation of certain artificial organic colouring matters. It is also utilised with other chemicals in the production of certain sulphur blacks (although these are rather unstable).

Picric acid was widely used during the war in the manufacture of explosives. The pure acid was used for filling shells with a mixture known
in Italy as pertite, in France as melinite, in England as tydallite, in Japan as shimoe. It is now, however, frequently replaced by trinitrotoluol for this purpose. It is also used in combination with other chemicals such as nitrotoluol to form explosives and is used in the manufacture of fireworks and tear gas (chloropiric). Picric powder makes a special variety of semi-smokeless powder. In laboratories it is employed for chemical analysis (reagent for albumin and alkaloids), and microscopic analysis, and to a lesser extent as a medicament, and in the photographic industry. It was formerly the practice to add it to beer to give a bitter taste and it is still sometimes fraudulently employed to colour certain foodstuffs (butter etc.).

Poisoning may occur among chemical workers (preparation of picric acid), munition workers (shell filling, manufacture of tear-gas), dye workers, woodworkers (mordanting) photographers, firework makers, laboratory workers, chemists, etc.

TOXIC ACTION

What is known of the toxicity of this product is based on observation of cases of acute poisoning, for so far laboratory research has not yielded exact knowledge on this point. According to Kobert and Erben picric acid, like nitrated substances, has a tendency to attack the red blood corpuscles and to form methemoglobin; it also has a strong coagulating action on albuminoids and marked caustic effect on organs in which acid is present — the stomach for instance. But since picric acid is easily changed in the system into the less toxic and less irritating picramic acid, this latter effect is ordinarily attenuated. Though certain authorities have found alteration in the number of red corpuscles (diminution) with increase of white corpuscles, others have only found slight eosinophilia without any modification of the blood.

Poisoning takes place principally through inhalation of dust and more rarely of fumes. The dust soils the hands and thence the food and can thus enter the system by the digestive tract. Absorption of picric acid through the unbroken skin (as with other nitrated substances) can be admitted theoretically, but actual occurrence may be doubted.

The dose poisonous for rabbits has been calculated experimentally by Eulenbert and Koizumi at 0.33 grm. per kg. (acute poisoning) and from 0.0045 grm. gradually increasing to 0.045 grm. per kg. for chronic poisoning. In 1918 Ilzhofer induced fatal acute poisoning in cats with a single dose of 0.5 grm. per kg. of an aqueous solution of picric acid, and death on the third day by administering two doses of 0.2 grm. per kg. When the dose was limited to from 0.05 grm. to 0.1 grm., repeated several times in course of a week, red fumes in Germany unaccompanied by any other important phenomena resulted. The formation of methemoglobin was never observed. Ilzhofer is of opinion that picric acid is more poisonous than nitroxylenol or nitronaphthaline.

STATISTICS

Statistics relating to occupational lesions and poisoning due to picric acid are very limited. Cases of dermatitis were reported in Great Britain in 1902, but it was particularly during the war that cases of cutaneous and mucous irritation and digestive disorders were reported and made the subject of careful study by experts. Fatal cases due to picric acid are much less frequent; three deaths were reported in 1906, one of which was the case described by Christnacht (1917) as having occurred in an explosives factory, while a second took place in Germany during the war. Slight cases of dermatitis have been reported more recently (1919-1922) chiefly in lamp wick factories. In one picric acid factory, however, no case was reported in the course of twenty years. The third fatal case was that of a worker who fell ill after emptying a receptacle containing liquid picramic acid and died after a few hours. It must be remembered that serious cases, some fatal, have been caused by nitrous fumes (during the nitration of phenol).

SYMPTOMS

A few minutes in a workroom where picric acid is being handled suffice to produce a bitter taste in the mouth and shortly afterwards the hair and the nostrils look yellow. This change of colour is quicker with blond than with dark-haired workers. The coloration of the exposed parts of the skin which is typical, is particularly marked on the palm of the hands. Yet despite this the general health of the workers is good and it may be said that the picric acid industry is not as unhealthy as was first thought (Koelsch). The quality of the acid and particularly its degree of purity, as well as individual susceptibility, largely determine the clinical picture.

The use of picric acid as a medicament, and its popularity with
malingerers anxious to escape military duty during the war, but especially cases met with in munitions factories, have brought to light the symptomatic poisoning of picric acid poisoning, but little known prior to 1914. Inhalation of this product rapidly causes — besides the characteristic yellow colouring of the skin and hair (head and beard) and mucous membranes — sneezing, sometimes violent catarrh, stomatitis, gastric pain, and vertigo. The so-called chronic form is accompanied by a bitter taste in the mouth, a lack of appetite (at first the appetite increases), a dry cough, accelerated breathing, anaemia — a state which rapidly improves and finally disappears if the victim is removed from contact with the product.

In the urine, poisoning is characterised by the presence of albumin, blood, haemoglobin and casts. Picric acid is eliminated in the form of picric acid into which it is perhaps transformed in the liver.

Picric acid reacts on the skin by provoking a scarlatiniform erythema, chiefly affecting the face, the neck and the limbs, and causing itching of the skin. In serious cases there is rise of temperature, headache, vertigo, accelerated pulse, vomiting, diarrhoea, and collapse.

In the industries in which workers are brought into contact with this product generally the only symptoms noted are dermatitis (especially in summer), conjunctivitis, and more rarely bronchitis. The bronchite meliniteuse (lydite bronchitis) mentioned by Regnault and Sarlet due to the irritating action of acid picric may be recalled here.

Cases are now much less frequent than formerly, and chronic poisoning and picric jaundice as described by certain authorities are doubtful (Curschmann).

**Demonstration**

(a) In the urine. — Add to 100 c.c. of urine 10 c.c. of a neutral 10 per cent. solution of acetate of lead, filter, add 20 c.c. of sulphuric acid at 25 per cent., filter, shake the filtrate with the addition of 5 c.c. of chloroform or ether, decant, add 5 c.c. of ammonia at 10 per cent. A red colour proves the presence of picramic acid. The following reaction may also be employed: acidify the urine with hydrochloric acid and mix it with ether, add to the ether extract (yellow) a slight quantity of caustic soda solution (lye); the ether becomes discoloured and the lye assumes a red colour.

Kohn Abrest advises the following reaction: treat 20 c.c. of urine with 10 c.c. of Denigès reagent (10 grm. red mercury oxide, 200 grm. water, 40 c.c. sulphuric acid) filter after 5 minutes; shake the filtrate with 5 c.c. of chloroform, separate the former, mix again with about 4 c.c. of chloroform, shake, leave it to settle, decant the chloroform and mix the two chloroform solutions, filter them if necessary, add ½ c.c. of water, put them in a test tube and drive out the chloroform by standing in water and heating the water. The presence of picric acid is shown by golden yellow colour of the liquid. It is advisable to repeat the reaction several times as a check on the test. Another method is to dip into the liquid obtained as above some strands of white wool or silk and discover whether the yellow colour imparted to these resists vigorous washing and changes more or less to a reddish tone when the strands are brought into contact with a solution of potassium cyanide to which potash or soda has been added and the whole slightly heated.

(b) In the blood. — Fifteen drops of blood are mixed with 3 c.c. of a 0.5 per cent. solution of sodium chloride which is left to stand for twenty-four hours at the temperature of the room, the mixture being stirred occasionally; a yellow hue, even with very slight, proves the presence of picric acid. The addition of an equal quantity of a methylene blue solution (1 : 50,000), the whole being then shaken, will indicate the presence of the product by pale to dark bottle-green colouring.

**Hygiene**

Though in practice cases of occupational poisoning are very rare, it is nevertheless advisable to apply the well-known precautionary measures against dust. It is indispensable that the grinding and drying of picric acid should be effected in closed and airtight apparatus. Dust elimination at the workplace should be effected by a downward or sideward drawing exhaust, the optimum rate for the air current being exactly determined (very light dust). It must be admitted that mechanical elimination of dust in this special case presents a problem which still awaits a satisfactory solution. The workrooms should be cleaned daily and all tools and implements maintained in a clean condition.

Manipulation and transport as well as packing of this product in the explosives industries should be subject to the usual precautions taken in regard to explosives.

Measures of personal hygiene comprise powdering of the face to prevent yellow discoloration of the skin; washing of the hair with a hot and concentrated alkaline solution and in close (it is preferable to wear the hair very short). The wearing of rubber gloves and impermeable overalls has been recommended (Great Britain). A
method to be recommended is the manipulation of picric acid in cupboards provided with adequate exhaust ventilation and having windows to permit of controlling the work in progress, or two apertures for inserting the hands.

The presence of metallic lead should be prohibited in places where picric acid is handled.

During the war several factories had all applicants for work medically examined and had their workers periodically examined. Milk was also distributed to the workers. Persons showing signs of poisoning should be immediately removed from departments where the product is present.

**LEGISLATION**

Exclusion of women from the manufacture of picric acid is enforced by legislation in Argentina, France, and Switzerland. For the Netherlands see article "Acrolein".

Compensation for injury caused by picric acid is provided for in Finland and Switzerland.

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Pitch

(Coal Tar Pitch; Tar Pitch)


**PROPERTIES**

Pitch is a solid substance with conchoidal fracture, brilliantly black, but at the same time smooth and sticky, constituting the residue from distillation of tar, or rather of tars, because the composition of these varies with the different kinds of coal from which the gas is extracted. Pitch dissolves partially in petroleum ether, petroleum benzine, alcohol (in small quantities), etc.

In addition to hydrocarbons, heavy oils (naphthalenes and anthracenes), light oils (benzenes and phenols), the tars contain a certain quantity of fixed carbon.

The hydrocarbons and oils are separated by fractional distillation; the black mass remaining at the bottom of the stills is pitch.

The amount of pitch collected from the tars varies between 30 and 80 per cent. This residue, itself very variable, is a mixture of anthracene, chrysene, pyrenes, resins, gums, coke, etc.

Pitches are divided into different categories; according to their melting point they can be distinguished as soft pitch ( fusible between 40° and 50° C.), hard pitch ( fusible between 70° and 100° C.), and semi-soft pitch with intermediate properties.

The proportion of pitch in the agglomeration of smalls can be ascertained by the simple means of breaking up a small sample. Those in the trade easily learn to gauge, by taste and plasticity, the quality of pitches (De Vulilch).

**USES**

Pitch is largely used in the manufacture of patent fuel (briquettes), artificial asphalt, impermeable pasteboard, varnishes for wood and metals, lampblack, insulating materials, etc.

When hot pitch, completely free of volatile matters, is mixed with siliceous materials of different degrees of hardness, a special product is obtained, known in commerce under the name of "Prodorite". This mixture can be moulded; it serves for the manufacture of pipes, blocks, etc., which can be joined with an impermeable cement of the same nature. It can be reinforced by steel, like cement. It is used to make chimneys proof against acid fumes, and for impervious floors, for electric accumulator rooms, vats, receptacles, etc., which are required to be resistant to acids, heat, pressure, etc.

Pitch (with tar) is used as paint in the construction of ships, the manufacture of accumulators, in the barrelling department of breweries, in the making of brushes (in the form of glue, either mixed or not with asphalt), in the making of lacquers, artificial stones (finely ground cork, mixed with molten pitch and compressed under a vacuum), etc.

Its use in the manufacture of patent fuel is very important. This consists in mixing and pressing coal dust with a certain quantity of pulverised pitch (8-10 per cent.) which is converted, on heating, into a paste and forced through a press into quadrilateral moulds and then cut into briquettes.

The mixing of the two powdered materials is done in an apparatus charged automatically; the paste comes from a closed pug mill provided with
mixing arms where it is brought to the temperature for the melting of pitch by means of steam jets.

The paste is then submitted to considerable pressure, and the continuous charge thus obtained is cut automatically by a rotating table pierced by openings, or simply by hand by means of a knife.

The briquettes are then filled on to wagons (work generally done by women on the Continent).

As soon as the mixture of the powders is effected, the operations are carried on in an enclosed apparatus and in a moist condition—that is, without evolution of dust. It is to be noted that persons employed in these operations do not show the characteristic lesions set up by pitch.

**Sources of Danger**

The hands of the charger are always in contact with the briquettes, that is, with tarry matter. Further, all around the machines and at the point of departure from the press a tarry smell is felt, obviously coming from the pitch. These gases and vapours do not appear to have an appreciable effect on the health of the workers; at any rate, no specific action either on the skin or the eyes or respiratory tract can be attributed to them.

Careful investigation of methods of work convinces one that only the workmen exposed to pitch dust are subject to these occupational injuries, generally designated as “pitch effect” (maladie du brai). It is especially the means of conveyance (elevators, endless belts) which create the very fine dust. Dipping or hacking out with a pick and crushing of the pitch, which reaches the factory in large lumps and sometimes even in cylindrical masses, raises quantities of pitch dust, which remain in suspension in the air for a long time. Digging is done generally in an enclosure or hangar, or even in a separate part of the building more or less distant from the machines. The pitch which has been dug out is conveyed to the disintegrator on trolleys pushed by hand; charging and discharging these raise quantities of dust, but it is especially at the point where digging is done that it is thickest and most injurious. At the moment of breaking up the pitch with the pick a characteristic odour of hydrocarbons, recalling that of pyridene, is evident.

Pitch dust floating in the air alights on the skin, the hair, the beard, and the mucous membrane of the eyes, nose and throat.

The injurious effect of these dusts depends for the most part perhaps on their chemical composition, but, by reason of the physical structure of the particles (sharply pointed, toothed and angular) their power of inflicting injury must be admitted (see fig. 76).

**Statistics**

In Germany the question of dermatitis and tumours among workmen manipulating pitch has been followed with the greatest interest. At Oppeln, in 1894, cases of conjunctivitis and dermatitis accompanied by the formation of crusts were reported among workers of a recently erected patent fuel factory. In Upper Silesia these lesions were already known, and also in Westphalia and Rhineland, where enquiry, made in 1895, showed that sensitiveness to the action of pitch varies in different individuals, and was most marked among young subjects with delicate skins and of a scrofulous type. Measures taken for individual cleanliness and general hygiene, efficient dust removal, especially in drying and pressing departments, have diminished the frequency of cases. The report of the enquiry of 1898 attributes these lesions to the presence of traces of phenol in the pitch. In 1901 it was stated that the workmen affected had been manipulating finely divided English pitch. In 1909, L. Zweig, of Dortmund, described three cases of pitch (or tar) tumours among patent fuel workers. He was of opinion that these substances exercised an action analogous to that of paraffin and lignite tar, causing not only eczema, but tumours also. Nevertheless the number of those attacked by the latter in relation to those exposed to risk was fairly low. He admitted, however, that these substances favoured or accelerated the development
of tumours in those who were predisposed. The number of occupational lesions reported in Germany is very small. Thus during five years only two cases a year were reported among 2,500 workpeople, i.e. 0.08 per 1,000. Of these the cases the lesion was located five times on the scrotum, four times on the face, and once on the forehead. In the cases of pitch cancer were reported in Hamburg.

In the United States, according to A. Hamilton the question has little importance, as the patent fuel industry is insignificant. Davis (1914) reported a case from use of an industrial oil (paraffin?) and a few cases have been collected by McCord and Kilker (1921) among 17 workers employed in treating wood with tar, pitch, and chloride of zinc.

On the other hand the matter is of great importance in Great Britain, where dermatitis and tumours are more frequent than elsewhere — no doubt because of compulsory notification by medical practitioners. These lesions have even been reported there among workers employed in discharging pitch from vessels and from trucks. The lesions are situated on the most different parts of the body: face, hands, scrotum, etc. Generally the lesion follows a benign course, leaving only a superficial cicatrice. But when the lesion is localised on the scrotum, not infrequently it becomes cancerous, as in this situation no doubt the linen impregnated with pitch irritates the parts. Operative interference, however, generally prevents or retards recurrence.

Unfavourable sites also are the eyelids and eyes (conjunctiva), and blindness is fairly often a sequel. Dermatitis and warts set up by pitch have been included in the list of diseases scheduled for compensation since 1905; since which time scientific researches on the subject have been very numerous. An enquiry in 1907 among the briquette makers of South Wales brought to light 38 cases; but previous to this no case had been reported during twenty-three years among the workmen making briquettes with tar and pitch. Hilditch, Inspector of Factories at Swansea, attributed these lesions to the action of crude anthracene, and Legge and Owen Edwards examined 277 workers in 1909, finding in the majority of them symptoms of irritation of the skin, enlarged sebaceous glands, and ulceration set up by the pitch. In 1911 a public enquiry was conducted under the Factory Acts by Mr. W. A. H. Lush, and it came out in evidence that the action of the pitch differed considerably according to its origin. The workers stated that pitch from Margport and Goole was much the most irritating. The yellow staining of their linen was said to be due to the presence of anthracene in high quantity — so much so that either anthracene or phenol was believed to be the cause.

Lush in his report recommended special clothing to protect the workers' skin against contact with pitch dust; use of goggles; means, other than soap, for ridiccling the skin of pitch without causing irritation, and medical supervision.

Ross and Cropper conducted researches from 1910 on different kinds of pitch in order to find the substance setting up the irritation. Coal tar pitch they found the most irritating, while blast furnace pitch was much less so. This view was found to be the case in actual practice by Legge. The acid sweat was believed by the experimenters to dissolve out the auxetic substances in the pitch which favours the development of new growths.

The employers in 1911 organised a voluntary periodic medical examination, and it is owing to this that detailed statistics for workers in briquette factories are available. From 1911 to 1919, 158 attacks (3 deaths) were reported among workers coming into contact with pitch. From 1920 to 1922 the cases numbered 79; in 24 of them the ages varied from 40 to 50 years, in 24 between 30 and 40 years, and in 8 over 60 years of age. Duration of employment had been in 16 cases less than 10 years, in 18 from 10 to 20 years, in 20 from 20 to 30 years, and in 12 from 30 to 40 years. The lesions were situated on the face and neck in 43 cases, on the scrotum and groin in 20, on the hands and forearms in 6, and multiple in 8; in 3 cases the site was unknown. In 1923 the cases reported numbered 85 (2), in 1924, 23 (1), in 1925, 25 (3), in 1926, 27 (3), in 1927, 34 (1), in 1928, 32, in 1929, 53 (3), in 1930, 44 (1), in 1931, 41 (2) and in 1932, 35 (1).

In Italy the cutaneous lesion among workers in a briquette factory at Ribolla were at one time so serious as to lead to temporary suspension of work.

The first enquiry into this subject was undertaken in the Netherlands in 1913, and had reference to only two patent fuel works, one which employed 47 persons (15 were under 17 years of age) and the other 8.

Irritation of the sebaceous glands was detected in 28 cases and furunculosis in one, on the face and forearm; in 7 there were cutaneous proliferation, and in 11 acute or chronic conjunctivitis.

Subsequently the personnel in all the patent fuel works were subjected to medical examination once or twice a year.

The results are given in the report of the Inspector of Factories for the years 1913 to 1924, and are shown in the table on page 654.

In 1913 and 1907 a medical examination of all the workmen employed in three factories revealed in the same factory 2 workers suffering from lesions due to pitch.

In 1913 one of these men showed cutaneous proliferations localised on the scrotum, of which one turned out to be sarcomatous. Four years later the same man had developed a tumour on the right wrist, which healed after an operation. The other man (with forty years' duration of employment) had an epitheliomatous ulcer on the scrotum. He had undergone an operation the year before for a similar condition on the same place.
The idea or associating pitch cancer with that of chimney sweeps is not new; there is a still more intimate connection between accidents due to pitch and those due to tar. Tar itch, dermatitis due to pitch, takes on many forms, varying from a simple acne to eczema and psoriasis. It occurs usually on the upper limbs, but is found also on the scrotum.

The carcinomatous degeneration of certain skin lesions has been observed by several authorities, among others by Volkmann, who has described one case of scrotal cancer and one of the eyelids due to the injurious action of tar. Mention only need be made of the innumerable instances of experimental cancer produced in mice by painting the skin with tar.

Chimney sweeps' cancer, like that occurring in persons employed with pitch, starts no doubt from the irritative action of various ingredients present both in pitch and soot, as well as in tar.

The noxious substances are believed by some to be phenol and naphthaline, by others creosote.

Bayet, interpreting the pathogenesis of pitch lesions, considers the morbid picture is not a single entity, but should be classified thus:

(a) the acute symptoms, exacerbated by light, Bayet believes, are the result of irritation by certain constituents naturally present in pitch, perhaps anthracene oils, an irritation analogous to that set up by a number of substances (turpentine, varnish, resin). It is natural to explain the matter in this way, but it should be made the subject of experimental verification.

(b) in the case of acne-like outbreaks he thinks it necessary to attribute to the action of tarry substances, and considers them to be similar to the well-known tar acne.

(c) in the case of pigmentation and hyperkeratosis, warts, and epitheliomata, he arrives at the conclusion which he was the first to formulate (in 1916), i.e. that they strongly resemble chronic arsenical poisoning.

Really, in Bayet's opinion, the third group is the one that should be considered as characteristically the pitch effect.

In a subsequent work this authority has confirmed this view, stating that, considering all the facts of the case as outlined above, the clinical picture observed in pitch workers in all the essential aspects, as well as in the details, resembles that of arsenical poisoning.

This conclusion has been confirmed by Slosse, who showed the presence of arsenic in the air of the factory on the one hand and on the other in the hair, blood and urine of the operatives in notable amount much in excess of what was physiological. An important point to remember from the point of view of prophylaxis is that the arsenic found in the air is not there in the form of vapour but of dust.

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Mention only can be made of the theory of H. C. Ross on malignant disease as due to the products of the decomposition of living matter and the effect in hastening it of kinetic and auxetic substances. Neither can more than a reference be made to the view that use of formaldehyde might neutralise the noxious ingredients contained in the tar.

Burkhardt (1920) has raised objections to this view, and has promulgated another, namely, that tumours of the bladder in aniline workers, for example,
and new growths observed in patent fuel workers may be due to the action of an organic compound present in the coal tar pitch, but which has not yet been identified.

If under the term "pitch effect" are included not only the symptoms of pigmentation, hyperkeratosis and cancer attributable to arsenic, but also the acute irritative action, it must be acknowledged that the etiology of these latter does require further elucidation.

Merely to say that pitch acne resembles tar acne does not advance us far in the search for the cause; to say that the acute symptoms are due to carbolic acid or anthracene oils is only to give a ready answer; as a matter of fact, carbolic acid being the most valuable constituent in tar, is extracted to the furthest extent possible, and is only found in very small quantity in pitch; on the other hand the content in anthracene is very variable.

In addition to the undeniable chemical action account must be taken of the physical constitution of the dust and of the opinion of Herman that insufficient attention has been paid to this aspect. Thus microscopical examination shows
these dusts to be capable of producing wounds. When falling on the surface of the skin they penetrate it readily as a consequence of the movements made in the course of work or by friction exercised by the skin. To set up conjunctivitis blinking of the eyelids alone is enough. Lastly, having regard to the thin skin of the scrotum and the friction to which the genital region is subjected in walking and working, it is not surprising that this should so often be the seat of election for injury from pitch dust.

Once having penetrated the tissues these dusts act mechanically and chemically, but it would be a mistake to suppose that they are quickly dissolved or that the irritation has no other cause than the chemical substances set free by this solution.

In the cores of an acne spot already old, Herman has found pitch dust with characteristics like those shown in fig. 76.

Possibly the course of events may be somewhat different in the case of eye injuries both physiologically and anatomically; but Herman wishes to bring out the fact that the action of pitch is not exclusively due to chemical action.

There is no doubt, on the other hand, that the effects of pitch often become complicated as the result of scratching and subsequent secondary infection. The curious fact of exacerbation, of the burning sensation of the skin from solar radiation has not yet been satisfactorily explained. According to Herman the idea of the melting of the pitch particles by the sun's heat must be rejected as the phenomenon is instantaneous. Sun heat can only act gradually and as a result of the warming of the surrounding air, but there is no doubt that warm air and hot water can themselves increase the sensation of burning.

It is more logical to admit the action of the luminous (and perhaps chemical) rays of the solar spectrum. These rays excite the nerve endings in the skin: this increase in the excitation of the nerves already initiated by the presence of pitch dust may help to explain the increased tenderness felt.

Interesting results might be expected from placing different coloured glasses before the face of workmen exposed to the sun, in order to determine the action of the different colours of the spectrum.

**Symptoms**

The effects of pitch comprise a heterogeneous ensemble of different lesions and symptoms which Bayet has classified in three groups:

1. **Acute irritative symptoms:** these consist of a pricking and burning sensation on the face, during and after contact with pitch. This sensation is only produced when the sun shines.

2. **Symptoms mainly of the hair follicles and sebaceous glands:** these comprise comedones, pustular acne, sebaceous cysts (tar acne).

3. A third group comprises as the principal symptom pigmentation, hyperkeratosis and cancer; as secondary symptoms chronic inflammations and cutaneous atrophies, telangiectasies, and xeroderma.

The use of pitch in painting has caused cases of poisoning due, it is believed, to small quantities of heavy hydrocarbons contained in the paints. Such symptoms as loss of consciousness, epileptiform seizures, and small rapid pulse have been noted amongst these workers. Ulceration of the nasal mucous membranes has also been found in the workmen making patent fuel (Oliver), etc.

So far as cancer specially is in question, Bayet assigns to it the following characteristics:

(a) it almost always develops on the site of a hyperkeratosis (wart or thickening of the epidermis);

(b) the seat is mostly on or near the scrotum;

(c) it is frequently multiple;

(d) it often occurs in those who are relatively young (among 9 pitch cancers 4 affected workers who were under 40 years of age).

An enquiry conducted in 1916 in several patent fuel works in Hainault and Liège enabled Herman to observe the correctness of the above view.

All the workers exposed to dust—but only these—experienced the burning sensation on the face and noted how this was suddenly aggravated by exposure to the sun's rays.

On the other hand the electric arc, deprived as it is of all heating properties, as ordinarily used, causes no aggravation of the symptoms.

It is undeniable, however, that to be in an overheated atmosphere, or, further, to wash the skin with hot
water, does increase the burning sensation in the face.

Herman has been able to establish the fact that the kind of pitch used plays a part in the seriousness of the effects. Thus the pitch worked during the last two years is more injurious than that worked in the years preceding, although it comes from the same places.

The signs of acne seen among a large number of the workers were very polymorphous; but it was generally observed that the acne spots were inclined to become hard and indurated.

In one case, however, Herman noted suppuration of almost all the pustules. The man in question was very dull mentally and took no care in the matter of personal cleanliness; infection of the boils following on scratching

Fig. 73. — Cancer of the Parotid Region.

Fig. 77 is a photograph of a workman employed for thirty years in a patent fuel works. Acne spots of various sizes are distributed on the back, shoulders and loins; they are seen too on the neck, where a marbling of the skin can be observed produced by a special pigmentation of the integument.

The skin of the scrotum presents a quite special aspect. Whitish, rather prominent maculae are scattered pretty uniformly over the surface. About
the size and shape of a lentil when isolated, they sometimes form confluent plaques covering a fairly wide area. Although raising of the skin is not pronounced, there is nevertheless a proliferation of the skin similar to that of a wart.

Fig. 78 represents a workman employed in handling pitch for 32 years. Fifteen years before the appearance of the epithelioma over the parotid region he had undergone an operation for the removal of warts on the scrotum.

The illustration shows well the base and edges of the ulceration with extensive epitheliomatous proliferation of characteristic aspect. To be seen also are the hyper and hypopigmentation of the skin of the face.

The pigmentation is not always confined to the skin; sometimes the hair and beard change their colour. Herman noticed amongst others a workman whose whole hair had taken on a curious yellow straw colour. In 1920 Scholberg, of Cardiff, examined 213 patent fuel workers and established the presence of two kinds of warts among these workers: (a) one, pendulous, which ordinarily causes no trouble, but if situated, as it often is, on the upper eyelid, annoys the workman; and (b) a flat form, with large base, appearing either singly or in groups, and often passing unnoticed, but which develops rapidly, degenerating, in the absence of treatment, into a cancerous condition. This form, however, is the less frequent of the two.

Lastly, besides the skin lesions, mention requires to be made of the eye changes. Moret has divided them into two groups: (1) lesions produced by the accidental impact of pitch into the tissues (these are rather in the nature of a traumatic injury) and (2) symptoms of irritative conjunctivitis and sometimes a special tattooing of the cornea.

Bayer refers to a hyperpigmentation of the conjunctiva like that met with in arsenical poisoning.

Prophylaxis

Should the discovery of Bayer and Slosse as to the rôle of arsenic in the production of the lesions of pitch he confirmed, the fact that it is not as vapour that the poison is present in the air would leave Herman's conclusion (1916) as holding the field, namely:

In the actual state of the question preventive measures against the effects of pitch are summed up in an effort to control the dust.

This proposition, though easy to state, includes a number of desiderata which it is not always easy to comply with.

So far as complete suppression of dust is concerned, it has been shown that this dust is only made in patent fuel works in the processes carried on between the point of discharge of the pitch from the wagon and the pug machine. If dust envelops the whole establishment, it is either badly kept or badly organised.

The ideal step would be to make the contents of the wagon pass into the disintegrator in a closed apparatus. This would necessitate suppression of hacking out or digging with picks and conveyance of the broken-up pitch on trolleys to the breaker.

No factory has yet been able to do this, and before it could be done it would be necessary to have a series of new machines; but there is no reason for thinking that the breaking up and mechanical transport of the pitch to the breaker are impossible automatically and in enclosed apparatus. It is a matter for the good-will of the employer, coupled with ingenuity on the part of the engineer.

Damping the pitch to avoid dust is attended with such serious technical difficulties as to cause its rejection; the pitch ought not to be wetted before breaking and mixing with coal dust. No ventilation, however powerful in itself, could remove the dust effectively.

Paradoxical as this may appear, it is easier to ventilate a closed chamber than an open shed: a draught of air produces eddies without much benefit; exhaust ventilation is hardly possible under the ordinary conditions of work. This is not, however, to say that patent fuel factories ought not to be effectively ventilated. It is easier to ventilate an enclosed apparatus than an open shed: a draught of air produces eddies without much benefit; exhaust ventilation is hardly possible under the ordinary conditions of work. This is not, however, to say that patent fuel factories ought not to be effectively ventilated. The ideal, therefore, is to strive for as the best means of suppressing dust is to carry out digging and conveyance of pitch in an enclosed apparatus. While waiting for this, attempt must be made to protect the skin by the use of different isolating substances; vaselines, starch, potato starch, a paste of clay or Fuller's earth, oils, etc. These measures are, unfortunately, precarious, because generally the methods of protection get removed during the work. Their protective action is moreover incomplete, but they are, however, of distinct assistance.

In view of the severity of the eye accidents, the wearing of goggles is important; but most of them only protect the eye from harmful splinters. The dust gets in easily between the glass and the conjunctiva; closely-fitting
goggles, like those worn by automobile chauffeurs, must be used. The use of a helmet provided with glasses would place the head, eyes and neck beyond the risk of dust.

The use of respirators or other things of this kind are of little use owing to the difficulty of breathing which attends their use during work. The clothing of workmen exposed to dust ought to be closed at the neck, wrists, and ankles. Daily use of douche baths is indicated.

In view of the frequency of lesions to the genital region, workmen informed of this ought to wash their hands before micturition.

Workmen who are suffering from the effects ought to be temporarily removed from the dusty atmosphere.

**Hours of work.** — Regarding 8 hours as the maximum, hours should be divided in such a way as to allow time between two shifts for necessary attention to the skin. The influence of the sun’s rays where digging is done in the open air should be avoided by a suitably arranged roof; one factory has used with success a moving roof fixed on rails, which can be taken, as it is required, to that part of the pitch bed where digging is in operation.

Treatment is a matter for the medical man, and must be left to him.

Truth to tell, the necessity for official regulations has already been felt in certain countries. Thus, in 1910 draft regulations were prepared by the British Home Office for the manufacture of patent fuel with pitch, as an injurious occupation, and such measures were asked for as the installation of baths and washing and cloakroom accommodation, provision of protective goggles, and hermetically-closed apparatus for disintegrating, mixing and conveyance of the pitch and coal dust.

The draft regulations were not, however, accepted, and the matter was left to voluntary adoption by the employers of such of them as they cared to introduce. The periodic medical examination, to which the workers were asked to submit voluntarily, has not proved successful. Thus, the number of workers examined at Cardiff fell from 119 in 1919 to 94 in 1920, 39 in 1921, 5 in 1922, 3 in 1923, and 6 in 1924. Results were no better in Swansea, as shown by the fact that, as compared with 158 workmen examined in 1920 (with 10 cases of epithelioma), 9 only presented themselves in 1921 (4 cases), 12 in 1922 (5 cases), 6 in 1923 (1 case), and 7 in 1924 (1 case).

It is true that at first the workers were very loth to avail themselves of the washing accommodation and baths in the factory, even when they were installed, because they complained that the action of the wind or sun on the skin immediately after a bath or wash caused severe pain and persistent irritation; but that is only true if the skin is already affected. It cannot be accurately stated that to rid a healthy skin of an irritating substance is harmful, as the baths are preventive and not curative.

The workmen themselves refused to adopt the prescribed means of cleanliness. The same arguments were adduced in the campaign against ankylostomiasis, when the suggestion of installing douche baths in coal mines was raised. Generally, every industrial measure calls for sacrifices on the part of the employer and for goodwill on the part of the workmen, and any lack of the latter does not constitute an argument against the application of desirable sanitary measures. Effort must be made to get workpeople to acquiesce in the measures of personal hygiene prescribed.

Another objection on the part of the employers is that the casing-in of the elevators involves considerable danger of serious explosion from the fine dust. But this danger must be appreciated at its proper value. A mixture of air and dust can be explosive, but in the present instance this eventuality is not based on facts derived from observation but on a priori grounds.

**Legislation**

Employment of women and young persons is limited to the same extent as in the case of tar. The employment of women and young persons under eighteen years of age is prohibited in the Netherlands in factories where patent fuel is made with pitch in closed workrooms. Compulsory notification of epitheliomatous ulceration due to pitch is required in Great Britain, France and the Netherlands for the following symptoms affecting patent fuel workers: skin affections (eczema and dermatitis), epithelioma and malignant tumours; pulmonary affections; conjunctivitis; inflammation of the tendon sheaths and sub-cutaneous cellulitis, ulceration of the cornea, and conjunctiva.

**Bibliography**


Plaster


Plaster is prepared from plaster stone or gypsum, a hydrated calcium sulphate (SO₄Ca₂(H₂O)₆), which abounds in nature.

Where present in the form of rhomboedral crystals it goes under the name of selenite; when in compact masses with dicalcium or gypsum, a hydrated calcium sulphate of Prof. M. Herman.

The photographs are reproduced by courtesy of Prof. M. Herman.

Prof. M. Herman (Mons).

Draft Regulations for the Manufacture of Patent Fuel (Briquettes) with Addi-


MORER. Congrès int. mal. profess. Bruss-
ells, 1910.

See also Schweiz. med. Woch., 1921, Nos. 13 and 14 (Hautkrankheiten).

The photographs are reproduced by courtesy of Prof. M. Herman.

Technical Data

Gypsum brought from the quarry is subjected for from twelve to twenty-four hours to the gradual action of heat in kilns, which are of three predominating types: (a) open-air kilns, (b) continuous kilns, and (c) metallic revolving kilns.

(a) The open-air kiln heated by wood or charcoal resembles a bread oven. Small arches are constructed at the base of the kiln with the largest pieces of gypsum, and smaller pieces and dust are heaped on top of these. Calcination is very slow; the product obtained contains over-baked plaster incompletely dehydrated gypsum and plaster baked to the required extent. This mixture provides, however, very good plaster. This kiln is of course not continuous.

(b) The continuous kiln is loaded from the top from time to time. The baked plaster is withdrawn at the base of the furnace. There are various types of kilns, but that most commonly used is bottle-shaped, the internal cavity constituting the hearth. The plaster circulates in the annular space between the double walls. The fuel is therefore completely separated from the plaster, which fact enables a very pure product to be obtained. The steam coming from the gypsum is liberated at the top of the kiln and the gases from the hearth are directed outside by tubular piping which passes through the double walls. Plaster stone, after crushing, is fed into the kiln by mechanical apparatus. The withdrawal is generally effected by shovelling. Certain types of these kilns are gas-heated.

(c) The revolving metallic kiln is heated by means of currents of hot air. Interior partitions arranged as baffle plates assure adequate stirring and mixing.

Withdrawal from the kiln is generally effected by hand or by shovelling subsequent to breaking, with a pick. For picking up the stones which are still hot, the workers are in the habit of wrapping rags around their hands to avoid burns.

At a first sorting, defective parts (not sufficiently baked or overbaked) are rejected. The others are sent to grinding which is effected in various ways according to the ultimate destination of the plaster—in ball mills or revolving mills (grind stones turning in a trough). The material is withdrawn by shovelling.

Bolting is only effected in the case of plaster of better quality intended for
The charging here is generally done by shovelling, but there exist certain entirely closed systems in which charging is also automatic and is effected by means of an endless screw or by a chain pump.

Plaster is finally stored. Automatic loading is gradually replacing hand work with a shovel, but more usually bagging takes place by means of more or less perfected apparatus analogous to that used for cement.

The industry comprises also preparation of artificial calcium sulphate by precipitating a soluble calcium salt (solution of calcium chloride) by sulphuric acid. It may also be obtained as a by-product in various branches of the chemical industry.

**Use**

The greater part of the plaster produced is used in construction. It is also used in sculpture, for moulding, in the manufacture of various objects (lighting and electrical apparatus, ornaments, etc.), which are plunged into stearine or paraffin, dissolved in ether or petrol, and colouring substances (gum, gamboge, dragon's blood) used to imitate sea foam. When the plaster has been mixed in a solution of glue and a small quantity of sulphate of zinc stucco is obtained, which is less absorbent than plaster and which takes on a beautiful polish and is used in the manufacture of mouldings and ornaments. Amongst other mixtures should be mentioned Paros cement, English cement, etc.

Plaster is likewise used as a raw material in the manufacture of sulphuric acid (see that article), as a loading material in paper pulp, in agriculture for manure and in the wine industry for the purpose of clarification. It is also used in pharmaceutical and surgical work.

**Sources of Risk**

Sources of risk consist for the most part in the escape of gases from the kilns (carbon dioxide, carbon monoxide, sulphur dioxide) and in the presence of dust from the plaster.

The gases in question are only of relative importance, for the kilns are situated in sheds open to all winds and once they have been lit the presence of workers on the upper platform of the kiln is no longer necessary. During emptying of the kilns, however, if the fire is not completely extinguished and the kiln cool the workers may be exposed to emanations of gas which are, nevertheless, rapidly dispersed by energetic ventilation of the sheds. From the health point of view the bottle-shaped kilns appear to be superior to open-air kilns, for their gases contain little carbon dioxide and no carbon monoxide or sulphurous fumes (Hébert, Mauté and Heim de Balsac). They ought, nevertheless, like the others, to be placed in open sheds.

Plaster dust, on the other hand, represents a much greater danger. According to Hébert, Mauté and Heim de Balsac, the most dangerous operations are the withdrawal from the furnaces of the fired plaster (breaking away of masses of plaster), the loading of barrows and the emptying of these, besides the troughs of crushing machines and the loading by shovelling of these troughs. It is the type of mill used in France and known as "Marie Salopes" which raises the greatest amount of dust. Grinding, charging of bolting machines, bagging, bagging and loading of wagons, are likewise dusty operations.

In course of the enquiry in question, the average content of the atmosphere in plaster dust varied from 0.075 grm. (discharging) to 0.400 (charging of the grinding mills) and 0.800 (storing) per cub. metre of air. According to this enquiry the quantity of dust inhaled daily by the workers engaged on the various processes of manufacture might theoretically be estimated at 0.114 grm. (emptying the furnace and loading the barrels), 0.581 grm. (bagging by means of hoppers), 0.710 grm. for emptying of the barrows into the grinding mills and up to 1.032 grm. during emptying of the barrels into the mills (Marie-Salopes).

**Statistics**

Statistics dealing with morbidity of plaster workers are relatively few and not of recent date. These workers constitute a floating population which may be entirely changed at any moment.

The enquiry conducted by Hébert, Mauté and Heim de Balsac (1909), covering 158 workers in plaster factories near Paris, did not succeed in establishing in an objective manner the effect on the mucous membrane of the nasal mucous membrane of the workers engaged in bagging. The morbidity in question is therefore of slight importance. Amongst 158 workers examined, varying from fifteen to fifty years of age, those who conducted the enquiry found dryness of the skin (158 cases), tuberculosis (6), dryness of the nasal mucous membrane with diminution of the olfactory sense (2), chronic catarrhal laryngitis (2), epistaxis (1), chronic catarrhal pharyngitis (1).
Further, amongst workers engaged in bagging there were 100 per cent. of cases of conjunctivitis, chronic rhinitis and redness of the pharynx.

**Pathology**

Numerous experts (Ramazzini, Fourcroy, Layet) consider that plaster dust represents a source of clearly defined occupational affections. Yet medical experts of the present time not only affirm it to be harmless (Hirth, Roth, Sommerfeld), but some even attribute to these dusts certain curative properties in the case of infectious pulmonary lesions, notably tuberculosis (Sommerfeld, Hacker).

According to Heim de Balsac, plaster dust does not cause occupational disease except in the case of workers engaged in bagging, all of whom, after a certain length of employment, suffer from chronic conjunctivitis.

The harm caused by plaster dust is connected especially with its strong tendency to absorb water, which causes it to become attached to the mucous membrane and form agglomerations in clogging thereof. It is for this reason that the descent of these dusts into the deeper respiratory passages encounters obstacles. Yet swallowing with the saliva and with food is on the other hand extremely easy.

Plaster of Paris, which is not in a state of fine subdivision, would appear to have a greater effect on the mucous membrane of the respiratory passages than the finely sifted plaster in the form of impalpable grains.

It has also been noted that constant contact with grains of plaster provokes inflammatory reaction of a mechanical origin, which is more or less severe, on the mucous membrane, on which it accumulates in considerable quantities.

It has nevertheless been established by experimental research that respiration of air charged with plaster dust is not injurious. The considerable solubility of plaster in water would lead to the supposition that its crystals have a tendency to dissolve when in contact with the mucous membrane, the soluble sulphate thus becoming absorbed and eliminated without accumulation in the system.

This does not hold good of dusts from polishing of stucco, which have been found encrusted in the mesenteric glands of workers handling stucco (the "adeno-gypsosis" of Robin), dusts which are insoluble by reason of the presence of particles of alumina and of insoluble mineral colours which the stucco contains.

These facts explain why the pathology of plaster workers is not very specific. It is reported that the skin of the hands is generally very dry, wrinkled and covered with cracks in the epidermis (Heim de Balsac) and at times ulcerated (Patisier). There is sometimes noted erythematous dermatitis (Roy) or eczematous dermatitis (Layet) amongst workers engaged in slaking plaster. Heim de Balsac reports a case of ichthyosis with desquamation localised on the external side of the arm and the upper part of the body.

There have also been reported cases of coryza and chronic rhinitis, dryness of the nose with diminution of the olfactory sense and the sense of taste and at times epitaxis, redness and dryness of the nasal mucous membrane and bleeding on the slightest contact (workers engaged in bagging). As regards the eyes, the most frequent injuries are chronic conjunctivitis, the intensity of which is said to be proportional to the length of employment (Heim de Balsac), marginal blepharitis, opacities on the cornea, which Heim de Balsac, however, did not observe.

Of less importance are respiratory lesions: pharyngitis (Layet) with redness and at times dryness of the throat, difficulty in swallowing, pharyngeal expectoration, benign chronic catarrhal forms of laryngitis with roughness and hoarseness of the voice, rarely of a granular type (Layet).

The pulmonary lesions indicated by older authorities would appear to have been attributed to plaster as a result of faulty interpretation. At the present time it is considered that plaster dusts do not cause pulmonary disease because they do not reach as far as the pulmonary parenchyma.

There have also been reported "stucco boils", from which the plaster workers who prepare wall and ceiling decorations suffer not only on the face and arms but often over the whole body. The plaster or stucco used is mixed with substances of vegetable origin, chiefly starch dextrine, etc., or other products such as asphalt, pitch, tar, in order to render the product applied impermeable, and these stick to the skin during perspiration and in the long run set up irritation and, as a result of obstruction of the orifices of the sebaceous glands, a type of folliculitis.

**Hygiene**

Measures dealing with the situation of plaster factories, as well as their construction, ventilation and installa-
tion, the working of kilns, etc., are similar to those already described in the article "Lime".

The most important measures relate to dusts raised during the operations of grinding, bolting, bagging, etc., which ought to be conducted under systems of localised ventilation or in a closed apparatus with automatic feeding devices. The transport of plaster between these various operations should also be effected automatically in a closed apparatus (see article "Dusts, Fumes and Smoke").

Precautions should be taken against noise, and likewise measures connected with the personal hygiene of the workers.

LEGISLATION

In Argentina women are excluded from operations exposing them to plaster dust. In Belgium young persons under sixteen are excluded from plaster-grinding mills where the dust is not evacuated by mechanical means. In Canada (Quebec) boys under sixteen are excluded from grinding and from crushing mills. In France young persons under eighteen are excluded from grinding mills and from kilns. In Italy boys under fifteen are excluded when dust is given off freely. In Spain boys under sixteen are excluded, and in Spain and Italy women under twenty-one years are excluded where diffusion of dusts in the workroom is not adequately prevented, etc.

There is no special legislation dealing with plaster factories. An Order of the Préfect de Police de Paris of 1 August 1930 prohibits manipulation of plaster in bulk and bagging of plaster in Paris, in the Department of the Seine, and on the municipal canals.

Measures against dust, which naturally come into play in this connection, are those issued under national codes of industrial hygiene.

BIBLIOGRAPHY


PLASTIC EARTHS

French: Terres plastiques. — German: Plastische or Feuerfeste Tonerde. — Italian: Terre plastiche or refrattarie. — Spanish: Tierras plasticas.

Amongst types of underground work, not the least interesting from the technical point of view, or from that of its effect on the worker's system, is the getting of plastic earths.

Whilst inhalation of schist or coal dust is apt to set up bronchitis, sometimes leading to pulmonary tuberculosis or even pulmonary disease in the absence of tuberculosis, amongst slate and coal miners, those engaged in plastic earth industry (as far as mining is concerned) may not assume in Belgium the same importance as coal-mining, it nevertheless gives occupation to an average of 954 workers in underground mines (365 at surface work) and 188 in open quarries.

Plastic earth is necessary in all refractory industries since it serves for the manufacture of crucibles (plate glass works, crystal, and zinc manufacture); smelting of ores or other products, sagger (firing of tiles in the pottery and china industries); making of special bricks (construction of tanks in the glass industry and lining of cupola furnaces in steel foundries), etc. The composition of plastic earths, which belong to the group of clays is as follows: silica-alumina — with traces of ferric oxide, calcium oxide, magnesium oxide and organic matter (of the lignite variety).

According to their content in alumina (which is of special importance) they are classified as lean earths (from about 13 to 18 per cent.), semi-lean earths (20 to 24 per cent.), and fat earths (up to 28 and 34 per cent.). Each of these divisions may be subdivided in its turn into first, second and third grade, according to colour, homogeneity and purity. The first grade is characterised by perfect colour and homogeneity, and is at the same time very pure (these constitute highly refractory earths). The second grade is characterised by its irregular colour (presence of marbling) and less homogeneity and purity. The third grade is also characterised by irregularity as to colour (yellow striation, traces of iron), and a much less homogeneous texture.
These earths are capable of withstanding very high temperatures (up to 1,690° - 1,730° C.), i.e. above the melting point of materials which may be contained in crucibles, tanks or furnace linings made out of these earths.

In the triangle formed by the Andenne-Namur-Ciney district where the principal mines in Belgium lie, there may be noticed small thatched huts scattered throughout the fields in groups of 2-3-10, each of which is situated on a pit of slight depth (about 20-50 metres) giving access to the galleries leading to the heading or working face.

Each pit generally gives employment to five workers, two at the surface and three below ground — two getters and one barrowman. A winch worked by the men at the surface, but sometimes driven by a horse, is used for lowering and raising workers, as well as of the blocks of earth obtained.

The air of the pits becomes vitiated by respiration, perspiration and excreta, by gas and smoke from carbide lamps when these are not burning well, by emanations from the wooden pit props, and gas from pockets made in former workings (inflammable gases which explain firedamp explosions often occurring in these mines). This air is renewed very inadequately and under great difficulty, with the result that during heavy or stormy weather, the workers may be obliged to leave the working face and return to the outer air.

Ventilation is effected by means of communicating shafts and zinc piping running from the bottom of the pit towards the top of the thatched roof of the hut and ending in a revolving chimney cowl.

In order to stimulate this rudimentary ventilation, a worker at the surface sets going from time to time a small hand ventilator, or sets on fire a bundle of straw at the entrance to the shaft.

It might be expected that in such an atmosphere the workers in these mines would suffer from very pronounced anaemia with a palor and breathlessness. Without a doubt their general appearance, their sagging gait and more or less leaden countenance certainly denote the harmful effects of hard work executed in a vitiated atmosphere and often in a bad posture. These workers usually look older than their years.

Fortunately, however, living in rustic and wooded surroundings, the life led out of working hours neutralises to a great extent the harm wrought by the unhealthy working conditions.

Standing, kneeling, crouching or lying on one side or the other, the getter,
On the right, cutting round the block with the scraper (instead of the tool).

On the left, inserting the tool into the earth to cut round the block to be detached (the worker is kneeling in order to enable a photograph of the tool to be made); on the right, the worker is cutting round the block and detaching it by means of the hoe.
Fig. 82. — Cutting the block by means of a steel wire.

Fig. 83. — Placing it on the truck.
armed with his "tool", that is to say, a sort of iron knife with a broad double-edged blade or a kind of elongated trowel with a double handle, drives it by means of violent and repeated blows into the sticky earth which is difficult to penetrate. In this way he manages to make an incision round a block in the mass which he then proceeds to detach and loosen with his hoe.

In making these efforts he breathes deeply, and then with a sharp outward breath he drives the tool into the earth. The effort is of necessity violent on account of the cohesive and gluey nature of the earth, and they are also subject to frequent repetition. In incision the worker has to give six blows with the tool, and driving it home once to the required depth necessitates six successive blows or, in all, thirty-six blows or efforts for each block cut out.

To complete the operation the worker uses his hoe in conjunction with his tool. This hoe requires to be driven in eight or nine times per block, and each of these successive operations requires five or six successive blows at the same spot or, in other words, forty efforts to detach each block. It is true that these efforts with the hoe are made rather at the expense of the arms, but it is nevertheless true that the respiratory system is called upon to furnish a perceptible part of the effort,

In making these efforts he breathes deeply, and then with a sharp outward breath he drives the tool into the earth. The effort is of necessity violent on account of the cohesive and gluey nature of the earth, and they are also subject to frequent repetition. In incision the worker has to give six blows with the tool, and driving it home once to the required depth necessitates six successive blows or, in all, thirty-six blows or efforts for each block cut out.

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to a series of efforts of deep inspiration and expiration, the pathogenesis of which has already been described in detail in the article "Effort".

An enquiry made by Dessent, of Namur, amongst these workers led him to remark, after examining a certain number, on the similarity of the subjective, objective and clinical symptoms affecting them.

Out of 28 workers examined, 21 complained of respiratory oppression, and in all or almost all cases Dessent found that the chest was to a certain degree barrel-shaped with increased distension and sonority on percussion and sounding, and expiration longer than the normal. These signs were met with, of course, in varying degrees according to the individual predisposition of the workers, the number of years they had spent in the pits in their ages. The conclusion is that the workers in question are prematurely aged.

The 7 workers who were free from respiratory oppression showed no other symptom of pulmonary emphysema; these exceptions may be explained by the fact that 4 of them were still young — under the age of forty though they had been employed for twenty years in the pits — whilst three others aged between fifty and fifty-nine had only worked for periods of one, six and ten years and had previously followed the occupation of quarryman or stone-cutter.

Amongst the 21 workers the difference between deep inspiration and expiration ranged from 7 to 10 cm., and those in which the difference attained 10 cm. were precisely the youngest (forty-one, forty-five, forty-six and forty-seven years of age). In the other cases the difference reached 13 cm.

The majority of the workers complained also of rheumatic pains varying as to site and intensity; these may be attributed to time spent in a cold, damp atmosphere. None of these workers was found by Dessent to suffer from eye trouble or nystagmus.

There is another method of getting the product (fig. 80), in which the worker, instead of a tool or a knife, uses a metal instrument (known as a scraper) to detach the block.

He draws two vertical lines, the depth of which he increases, and joins these parallel lines at a distance of about 50 or 60 cm. by horizontal lines of a given height, and completes the work by detaching the blocks by means of his hoe and causing them to yield. In this method the worker is no longer obliged to work "on his stomach". The arms and especially the muscles of the dorsal lumbar region are brought into play. In this way less strain is put upon the chest than in the first method described above (fig. 79).

According to Dessent, the plastic earth getters do work which is at least as trying as that of coal miners. They are prematurely aged and their working capacity from the age of fifty-five onwards is considerably reduced. Without doubt they do not all or almost all die towards the age of fifty or fifty-two like slate workers; they do not suffer like coal workers from pulmonary anthracosis likely to lead to phthisis; yet all of them suffer from chest affections, and the pulmonary emphysema which attacks them may lead to aggravation of the slightest affection of the respiratory passages, causing simultaneously cardiac insufficiency, especially of the right heart. Workers engaged in getting plastic earths should therefore be placed in the same category as regards sickness and old-age insurance as slate workers and coal miners.

Another very important question to consider is the improvement of the present conditions under which these workers are obliged to work.

Modern technique, with a little humanity could speedily give excellent results.

The ventilation should be improved to secure evacuation of vitiated air and the provision of pure and periodically renewed air for the worker in the pit. An improvement of the kind would rapidly counteract the poisoning and anaemia generally suffered by these workers. The first method of getting should also be abolished and replaced by the second, or at least the second should be extended by education of the workers and as industrial requirements allow. It is also essential that electric lamps which are less unhealthy than carbide lamps should be introduced.

(See also article "Mines (Hygiene in").)

The photographs are reproduced by courtesy of Dr. Dessent.

Dr. O. Dessent
(Namur).

Platinum

French: Platiné. — German: Platin. —
Italian and Spanish: Plátino.

Platinum (symbol Pt) and likewise the other metals of the same group (ruthenium, rhodium, palladium, osmium, iridium) are found only in their natural state mixed with each other and often with gold or iron. These
metals offer some difficulty as regards complete isolation since their salts possess many similar properties.

Platinum is at present almost exclusively extracted from the sandy deposits of the Ural Mountains (U.S.S.R.). This sand, subsequent to levigation, leaves a grey mass containing 75 to 85 per cent. of platinum and a small quantity of 5 or 6 per cent. of other metals of the platinum group and sometimes of gold, when separated by amalgamation. Platinum is also encountered under the form of arsenide (sperrylite) in copper or nickel ores (Canada).

Platinum in the pure state has a silvery aspect, but when finely subdivided it has a black colour ("platinum black"). It commences to melt at 1,755° C. It is malleable, very ductile, and resistant to air even when hot. In the cold state it resists effectively the action of all chemical agents but less so than platinum is on the other hand attacked when hot by several chemical products: alkaline hydrates, phosphorus, cyanides, sulphides, halogens, etc.

In Russia, the sand after levigation and sifting (with a view to the removal of the heavy and precious parts) is subjected to treatment by the wet method (Wollaston), which consists in treating the mass with aqua regia. The residue contains osmium, iridium and a solution of chlorides of platinum, iridium, rhodium and palladium, which with caustic soda form when hot IrCl₃ and soda hypoehlorite.

Ammonium chloride is added and chloroplatinate of ammonium is separated which, when hot, deposits spongy platinum. The spongy platinum is transformed into compact platinum by melting in a refractory crucible placed in a simple furnace heated by an oxy-hydrogen flame. It is then cast in bars which are subsequently hammered and drawn out into sheets or very fine wire.

When gold is present, the mass, after sifting, is submitted to an amalgamation process for separating the metal. Purification by the dry method (Deville and Debray) consists in heating the ore with lead and galena. The lead takes up the platinum, which may be liberated later by cupellation.

The platinum obtained in general contains iridium which is left in the case of commercial platinum. Chemically pure platinum is rarely prepared.

It is used in the manufacture of laboratory apparatus and articles (crucibles, wires, fine sheets, etc.); in the jewellery industry, in dental processes, in the preparation of "pallo-

rium", an alloy of gold, and of metals of the platinum group, with even greater resistance than the latter and costing much less; in the chemical industry (under the form of "platinum asbeslotts") for catalytic processes; in electro-technical work (for contacts); for the manufacture of platinum salts (chloroplatinate of potassium, used in photography; platino-cyanide of barium, for the manufacture of fluorescent screens; radiography), etc.

Platinum is not toxic. Though largely utilised in industry, it has never given rise to injuries of an occupational origin.

In the course of purification by the dry method, the workers are exposed to the action of lead fumes (lead, galena). In treatment by the wet method, the aqua regia liberates irritant acid fumes, whilst in the course of the operation there may also occur liberation of osmium fumes.

Medical literature contains particulars of the case of a worker who on opening a bottle containing platinum-oxide of ammonia and nitrooxide of platinum developed erysipelatoid patches on his face with a sensation of burning and itch, and as a result of contact with small quantities of the product, similar lesions on the fingers (Lewin).

Oxide of platinum has also caused eczema of the hands, the forearms and lesions on the nails.

In a platinum refinery, platinum in a spongy state melted in a refractory crucible liberated white fumes, whilst the flame rising from the crucible (heated with an oxy-hydrogen flame) turned greenish. The workers and the chemist who were supervising the operation paid no attention to this phenomenon, being of the opinion that the cloud which arose was due to the ammonia salt contained in the crucible and the greenish colour to impurities in the copper. Some hours later however the workers complained of headaches and general discomfort. The chemist in his turn two hours later suddenly experienced discomfort: weakness, attack of vertigo, remarkable acceleration of respiration and of the pulse. His breath smelt very strongly of garlic and this odour persisted for ten weeks. The platinum had been prepared from the residues of gold-bearing ore from Russia and Siberia containing tellurium (see article "Tellurium").

From the point of view of hygiene, work on platinum demands the same precautions as those issued for the extraction, casting and refining of metals: cement flooring of the work-
PNEUMATIC TOOLS

rooms, ventilation of the workrooms, precautions relative to the catching and evaporation of acid and toxic fumes; treatment of the ore and residues under large hoods with adequate exhaust ventilation; measures of prevention against the risk from lead poisoning are also necessary. Waste water requires to be neutralised before being allowed to enter drains or to run outside the factory.

Pneumatic Tools
(Compressed Air Hammers, etc.)

French: Marteaux pneumatiques; Outils à air comprimé. — German: Lufterduckhammer; Pressluftwerkzeuge. — Italian: Martelli pneumatici; Utensili ad aria compressa. — Spanish: Herramientas neumáticas.

TECHNICAL DATA

The advantages to be gained from the use of compressed air as motive power suggested its employment for a variety of tools and machinery ordinarily worked by hand. A remarkable increase in output and power is thereby attained. These tools are thus analogous to machine tools, but have the advantage over real machines of simplicity in construction, lightness, and size. They can thus be easily carried and manipulated under conditions and in surroundings where machines could not be used.

They are known under the generic name of "pneumatic hammers" because compressed air was first applied to hammers: but afterwards it was applied to other implements involving some kind of percussion stroke, such as rams and chisels, as well as to tools having a rotary motion, as for example for drilling and polishing, and finally to tools of mixed function, both hammering and rotary, such as drills.

The field of application for pneumatic tools so far has been more or less limited to work on rocks, stone, earth, minerals (coal, lignite, sulphur, precious stones), wood, and metals, but they can be used on other materials.

The principal operations carried out are the following:

(a) with hammers: hammering and ramming metals, splitting, dressing or shaping blocks of stone, caulking and fixing metal sheets and parquet flooring (fig. 85);

(b) with rams: breaking of ground, sand (in foundries), cement (fashioning or moulding pipes, etc.), or concrete road making, reinforced concrete, fashioning stones or artificial blocks (figs. 86 and 87);

(c) with chisels: reducing the size of stones, cutting, dressing, roughing, chipping, grooving, lining, engraving, chasing, scaling (ships, boilers, gratings, etc.), scraping, scouring and freeing from adherent sand, steel pieces, caulking, etc. (figs. 88 to 92);

(d) with portable drills: perforating wood, stones or metals (fig. 93);
The possibility of executing the different jobs in question, or others which may in future be effected by pneumatic tools, depends partly on the shape of the extremity of the tool or of the part intended for the work (drill, wheel, etc.) and partly on the kind of movement (knocking, rotary, or mixed). All pneumatic tools, however, have one part in common, the valve box, which has the same object as that used in machines worked by steam.

This box contains a piston, on the ends of which compressed air alternately exerts pressure, causing a to-and-fro movement with a speed varying from 700 to 1,500 blows and more per minute.

By means of special arrangements, the alternating linear movement of the
piston can be converted into a rotary movement of the collar, which carries the drill or wheel, and consequently a to-and-fro, as well as a rotary, movement can be obtained immediately.

A flexible pipe connects the valve box with a reservoir of air, maintained under a pressure of 3 to 5 atmospheres by means of a compressor or vacuum pump.

The air as it passes through the valve box sets up a loud and disagreeable noise, comparable to that of an internal-combustion engine. Its entrance into the box is regulated or suspended by the workman by means of a valve, worked by a button or lever.

The rapid change of direction the air undergoes inside the box and the oscillations of the piston set up a rapid vibration of the tool, more or less powerful, which is transmitted to the body of the workman.
The shape, volume, and weight of compressed air tools vary much, according to the use to which they are put; they can be as heavy as 25 kg. or more. So far as the shape is concerned, the small hammers used for fine work on marble and other stones that are not too hard are cylindrical; the worker holds them with his fingers like a pen when writing in the position designated by medical men as "obstetric" (fig. 89). The hammers that are a little larger are grasped in the fist; other heavier tools have a handle, reminding one of the butt end of a revolver, when the
instruments can only be held by one hand (fig. 92); or if the workman must hold them with his two hands (fig. 93), they may take various forms — crank, horizontal bar, etc.

When light hammers are in question, the right hand supports and pushes the tool forward, while the left hand guides the drill (hammer or chisel) which is simply fixed to the part carrying the valve box. Heavier hammers have the drill screwed tightly so that it forms part and parcel of the tool. The weight of the tool falls more or less on the workman, on account of the position he has to assume to carry out his work. It amounts to practically nothing when the tool is directed from above downwards, and reaches its maximum in work from below upwards. Under these conditions, the tool often cannot be held by the hands alone for long at a time. It is for this reason that the workman applies the tool to the arm bend or to the thigh (fig. 96) or the shoulder, with his legs wide apart to increase his power of resistance and make a bridge. In many other cases the tool is suspended by means of cords or metal bars, as e.g., in riveting nails and scaling the bottoms of ships, ramming sand or concrete (fig. 91) or for certain operations in riveting (fig. 98).

In other cases, again, the tool is sometimes mounted on supports, or attached to metal columns firmly fixed in the ground or walls of the place (fig. 99). This position can often be adopted in work carried out in narrow spaces, such as the roadways in mines, holds of ships, etc., and especially in work entailing piercing. When this method of fixation is used, the pneumatic tool is converted into a real machine tool, acting without recourse to the muscular force of the workman. The latter has only to place the tool in position and regulate its action. In all other cases, use of the tool demands considerable expenditure of muscular energy, never less — and often much greater — than that necessary to execute the same kind of work with ordinary tools (see later). But production is many times greater, because to the muscular force is added another more powerful and regular force, continuous and unremitting, viz. that from compressed air.

Study of the Movements

Careful analysis of the method by which pneumatic tools work shows that the effect on the neuro-muscular system differs from that produced in the case of ordinary tools. Of the three principal elements to be taken into consideration — that is, the importance, the duration, and the rhythm of the effort — the importance of the effort only can be equal to, or sometimes even less than, that demanded from ordinary tools, whilst the duration of the muscular contractions, and especially the rhythm, are always increased in a remarkable way.

To show this it is sufficient to analyse briefly the movements necessary to execute different jobs with a chisel, which constitute the most typical and commonest example of work with pneumatic tools in their different shapes for chipping, cutting, roughing, chopping, grooving, lining, and caulking.

When a workman strikes the head of a chisel or drill with his hammer to chip or penetrate stone or metal, the blows follow one another at a varying rate. Generally the interval is greater the stronger the blow required; but the workman can always regulate the rhythm as he wishes. All the muscles of the arm rest simultaneously in the intervals between one blow and the next, and antagonistic groups of muscles rest alternately, the one when the hammer is raised and the other when it strikes its blow. Even contraction undergoes differing degrees and phases according to the different positions of the hammer. This is why in periods of activity alternating with more or less long periods of rest signs of fatigue are consequently absent or retarded.

In all mechanical work done by the muscles it is of great importance if fatigue is to be avoided that the rest pauses between the requisite contractions should exceed in length the duration of such contractions. In work with a pneumatic hammer, however, this rule is not observed; in work with an ordinary hammer it rarely is.

But when the workman uses a pneumatic tool, always supposing that the

![Fig. 99. — Compressed air boring tool supported by a vertical column.](image-url)
weight of the instrument and the resistance of the material worked are equal, the progress of the chisel over the surface or into the stone follows on blows so near one another that the muscles of the arm may be kept in a state of permanent contraction, either to counteract the jet of compressed air so as to obtain perfect and constant adhesion of the tool to the object, or to get up the necessary force to secure the complementary pressure indispensable to make the tool advance over the object in question.

In these circumstances, the importance of the effort is hardly ever higher than that required in the first case, but its nature is very different because the alternating movements in hammering, which bring into play different groups of muscles in the two acts of the raising and falling of the hammer, are replaced by permanent or static contraction of all the extensor and flexor muscles of the arm. The two forms of work, therefore, are almost as different in their effect on the muscles of the lower limbs as an upright position and a walking position. Further, the effort of the hand and arm muscles demanded by the permanent contraction is increased in a remarkable way by the continuous tremor, the result of the vibration of the tool. These two factors notably aggravate the causes of fatigue.

**PATHOLOGY**

Work with pneumatic tools is attended by certain morbid phenomena, which cannot, however, be considered as due to specific causes. On the contrary, they are the result of ordinary causes aggravated by particular conditions under which the work is done. When first using these tools, the workmen complained very often of the many different ways in which their health was affected, and these they attributed to the new type of tool. Gradually all these troubles became so rare, that it is difficult to admit to-day that there is any special pathology resulting from pneumatic tools. Practically the same phenomenon has taken place in regard to them as took place when pedal machines (sewing machines, pressing machines, etc.) were introduced — that is, the annoyance and injury reported when the workers first handled them lessened remarkably the more they became accustomed to them. The effect, however, may be most marked after the worker has used pneumatic tools for some time (Middleton).

The most outstanding sign is a vasomotor neurosis or numbness of the fingers, designated as "dead fingers" and reported by Lockera, 1911, at Rome, and since then by F. E. Barnes, at St. Louis (Mo.), among stonedressers — exclusively among those who hold the tool with their fingers stretched out. This neurosis is characterised by pallor, sensation of cold, tingling, and loss of sensation and movement of one or more fingers — phenomena always aggravated by cold. Blanching, however, may occur on cold mornings when the hands are immersed in cold water and before starting work. The tingling and loss of sensation cease generally after a short rest; the pallor is said to disappear even while work is going on, and is replaced by a slight hyperaemia, or sometimes by real cyanosis, which is often accompanied with sensation of warmth. In some cases, the loss of sensibility, or the "dead" feeling, lasts several hours, but no case of this symptom remaining permanently is known.

After work has ceased, a slight tremor of the hand is found, even some hours after.

Some workers, especially when commencing the use of pneumatic tools, complain of some diminution of muscular strength, of the arm feeling constantly asleep, of various digestive troubles, insomnia, headache, disgustitude, change of mood, etc.

These latter phenomena are evidently the same as those occurring in the first stages of fatigue of any kind. There is nothing characteristic about them, and they cannot be considered as symptoms indicative of anatomical or functional lesions of the neuro-muscular system. Even the phenomenon of "white fingers" must be attributed to local effect on the circulation, produced by muscular contraction and cold. It is the cause not only of the pallor and chilling of the skin, but also of the diminution in sensation and movement.

In November 1916, J. L. Miller, of Chicago, described in a stonedresser a clinical picture very like Raynaud's disease, which was attributed to the use of pneumatic tools. At the wish of the Stone Workers' Associations, the Labour Statistical Office organised an enquiry which was entrusted to Dr. Hamilton. She studied the question as affecting stonedressers in several centres, and was able to show that the troubles described by the workmen, which consisted mainly in affections of the circulation in the hand, particularly of the fingers ("dead fingers"), were very frequent. The concomitant action of cold
must also be admitted, because the troubles were most marked during cold weather. The fingers said to be most affected are the index finger and thumb, but other observers (e.g., Middleton) have found the ulnar digits of the left hand to be also affected. Continuous work with pneumatic tools provokes and aggravates the injury, which is not produced when work is done with small tools or when use is not made of pneumatic tools. The conclusions of Hamilton were that the lesion was due to three factors — long continued muscular contraction of the fingers holding the tool, vibration transmitted by it, and the action of cold.

In the report of the Chief Medical Inspector of Factories (England) for 1925, Drs. Bridge and Middleton give particulars of an examination of four masons, who used pneumatic hammers. They concluded from the enquiry that, under the present conditions of work as carried on in certain districts, the factors leading to the injuries complained of were as follows: pressure exerted by the instrument which hindered the circulation in the fingers (especially of the left hand), the action of cold due at least partly to the compressed air escaping from the tool and exercising more marked action by reason of the fact that the rate of the circulation was reduced, and in part to lack of heating in the workshops.

Certainly, such conditions might give rise to a measure of general discomfort, but no obvious data are so far available in regard to permanent affections acting on the system in general or on the nervous system of workers using the tools.

Thor Rothstein has studied 8 analogous cases, in which there was marked vasomotor disturbance localised in the hands and diminution in sensibility. N. A. Cary (Camp Douglas, Ill.), has described 8 cases of vasomotor troubles of the fingers among soldiers who had worked for from four to fourteen years with pneumatic tools as stonedressers. J. P. Leake, of the Public Health Service of the United States, undertook an enquiry among stonedressers in Indiana as to the injury set up by these tools. He found that the hands of the workers using them presented a hypertonicity of the vessels, which itself constitutes an exaggerated reaction against low temperature. This fact is said not to be serious, but is certainly a cause of lessened occupational activity.

Similar researches were made at the same time by Edsall. Medical men, on behalf of employers' associations, have studied the question and described or discussed certain cases. From a report by A. P. Herring, of Baltimore, the two tables on pages 677 and 678 are taken, which show that a differential diagnosis can be made between "white fingers", and neuritis, neurosis, Raynaud's disease, acroparesthesia, etc.

The very detailed study recently published (1926) by the Institute for Occupational Diseases in Leningrad, in regard to occupational diseases reported as occurring amongst the Russian boiler-makers using compressed air tools, is reviewed in the article "Copper Boiler Making".

The vibration set up by these tools would not appear to have any particular significance, nor can it be held to be an element capable of setting up specific troubles of sensation or motion. It is in fact known that vibration does not produce them in many other conditions under which it occurs, such as, e.g., railway travelling, driving a carriage, or work on or near machinery subject to marked vibration.

It must be considered, on the other hand, exclusively as a factor which may hasten or aggravate the manifestation of fatigue.

Although there is a great similarity in the pathology of "dead fingers" and cramp (forms of cramp belonging, too, to the vasomotor neuroses, showing themselves generally in the winter and associated very often with local effect on the circulation, sensation of cold, pallor, painful lowered sensation, etc.), no case has yet been described of muscular spasms produced when the necessary associated movements are carried out in holding and keeping in position the pneumatic tools with the fingers tense and contracted. This fact can perhaps be explained by the small number of workmen who hold the tool only with the fingers, either by the discontinuity of the movements (as with pneumatic tools alternates with that with ordinary tools), or because the muscles do not execute any movement of their own but are in a state of tonic contraction during the whole time that work is carried on.

Loriga has also enquired into the frequency and gravity of general effects produced by pneumatic tools, and has found that they depend on the individual worker, that is to say, on the greater or less personal susceptibility to fatigue. Among other troublesome effects, induced secondarily as a result of work with these tools, are:

(a) lesions due to pressure or repeated shock of the tool on the hands and other parts of the body to which the tools are applied as, e.g., callosities, hygromas, tenosy-
### Comparative Diagnosis of Neuritis, Occupational Neurosis, Chilblains and "White Fingers"

<table>
<thead>
<tr>
<th>Neuritis</th>
<th>Occupational Neurosis</th>
<th>Chilblains</th>
<th>&quot;White Fingers&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usually symmetrical.</td>
<td>Not symmetrical as a rule.</td>
<td>Caused by exposure to dry cold, or even to damp cold air, with sudden increase of temperature caused by going close to the fire.</td>
<td>Not symmetrical as a rule.</td>
</tr>
<tr>
<td>More frequent among men — depending upon occupation and use of alcohol.</td>
<td>More frequent among neurotic persons.</td>
<td>May affect any exposed part of the body, i.e. nose, ears, fingers or toes.</td>
<td>Occurs among men who use steel chisel during cold weather, on marble, granite, or structural iron work.</td>
</tr>
<tr>
<td>Attacks the nerves of the feet and hands and extends up the limbs.</td>
<td>Develops gradually and affects the muscles used in a particular occupation.</td>
<td>If severe there is pain.</td>
<td>Affects only the fingers of the left hand.</td>
</tr>
<tr>
<td>Severe pain along course of nerve.</td>
<td>Some pain and stiffness or cramp of muscles. No pain along course of nerve.</td>
<td>Part gets red, swollen and hot, and itches. May break down into ulcers.</td>
<td>Not accompanied by pain, redness or swelling.</td>
</tr>
<tr>
<td>Signs of Inflammation.</td>
<td>No signs of inflammation.</td>
<td>—</td>
<td>No sensory changes of a permanent character. No change in the nerves or blood vessels of a permanent character.</td>
</tr>
<tr>
<td>Sensory changes.</td>
<td>No sensory changes.</td>
<td>—</td>
<td>No muscular weakness, tremor, or cramp of muscles. Numbness and paleness of fingers relieved by rubbing or placing part in warm water. Recovery during warm weather. Recurrence during cold weather.</td>
</tr>
<tr>
<td>Weakness of arms or legs; finally paralysis.</td>
<td>No paralysis of part. Recovery usually good.</td>
<td>Recovery usually good; recurrence on exposure to cold.</td>
<td>—</td>
</tr>
</tbody>
</table>

Novitis, and subcutaneous cellulitis;

(b) lesions due to forced or vitiated attitudes (kyphosis, scoliosis, deformities, etc.);

(c) pulmonary emphysema and arteriosclerosis of the extremities;

(d) affections produced by the noise on the organ of hearing and the nervous system;

(e) lesions due to the dust, of which the quantity ought certainly to be borne in mind when work takes place in a confined space (mine roadways, for example), because these dusts increase in proportion to the rapidity of the work.

### Hygiene

Prevention of the effects set up by fatigue depends mainly on limitation of hours of work, or alternation of work with pneumatic tools with other work, demanding less continuity of effort, or bringing into play other groups of muscles. Duration of rest pauses should be by so much prolonged as the importance of the elements increasing the intensity and duration of the effort is greater.

Among the elements should be specially mentioned:

1. **The form of the tool and the way in which it is grasped.** — Tools of cylindrical form, which are grasped only with the extended fingers, fatigue the groups of muscles entering into action more than those which can be seized with the full hand and than those requiring a special grip (tools with handle like revolver butt, with a crank, or horizontal bar). These, therefore, are to be preferred whenever possible.

2. **The weight of the tool.** — Effort increases not only with the real weight but also with the position in which the instrument is placed. The position from...
<table>
<thead>
<tr>
<th>Reymond's disease</th>
<th>Acroparesthesia</th>
<th>Erythromelalgia</th>
<th>Scleroderma</th>
<th>&quot;White fingers&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetrical gangrene.</td>
<td>Symmetrical in character.</td>
<td>Symmetrical in character.</td>
<td>Usually bilateral in character.</td>
<td>In majority of cases affects only the fingers of one hand (usually the left).</td>
</tr>
<tr>
<td>Attacks extremities. Usually fingers, toes, etc.</td>
<td>Tips of fingers usually affected.</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Not caused by occupation or changes in temperature.</td>
<td>Not affected by temperature.</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Paroxysmal. Severe pain precedes the attack, parts are numb, pale and waxy. A blue-red discoloration of skin on symmetrical parts often followed by gangrene. Mental symptoms of depression and gastric disorders often occur.</td>
<td>Pains in fingers very severe, with numbness and pallor. Pallor of fingers and hands. No discoloration. No gangrene.</td>
<td>Begins with burning pains and reddening of the skin of the distal part of the feet. Skin is red and swollen.</td>
<td>Pain, numbness and a feeling of tenseness are present. Pain not severe. Skin becomes hard and tense. Has a glass-like appearance.</td>
<td>Sensory changes not marked.</td>
</tr>
<tr>
<td>—</td>
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<tr>
<td>Parasthesia and pain.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Movement of the affected parts are hampered.</td>
<td>Condition is usually chronic but life not endangered.</td>
<td>Extends over many years with remission.</td>
<td>—</td>
<td>No weakness or paralysis.</td>
</tr>
</tbody>
</table>

above downward is the most convenient; that from below upwards the most distressing. With tools of weight exceeding 15 to 20 kg., work cannot be continued for more than four to five minutes, when all the weight of the tool has to be supported by the body; rest periods exceeding the duration of the working spell should then be introduced.

(3) **Air pressure** — A high pressure increases the number and violence of the repercussions of the tool, and increases consequently the effort of resistance and propulsion which the arm has to sustain, as well as the vibrations transmitted by the tool to the muscles. Observations by Loriga indicate that the pressure of the air ought not to exceed \( \frac{3}{2} \) atmospheres to render continuous work possible. The vibration produced by high pressure can be lessened in great measure by holding the instrument with the hands covered with large woollen gloves, or inserting between the skin and the tool a suffi-
cient layer of very soft material. This measure helps to counteract formation of callosities, cellulitis, tenosynovitis, etc., which may be set up by the tools.

Heavy tools placed on supports often have a grip which is fixed to the support itself by means of elastic catches with the object of lessening the vibrations. This arrangement does not apply to less heavy tools held by the hand.

(4) The position of the body and the manner of holding the tool. — The degree of fatigue varies markedly according to whether the tool is held with the single hand or with the two together, or is supported by and weighs upon the arms, shoulders, and thighs. The degree of fatigue varies also according to the position of the body; that is why, when it is possible, the tool should be hung by means of cords or fixed by supports in the form of a column, or on wheels, or fixed on the ground or on the walls; that is to say, every means which circumstances can suggest should be used in each particular case.

The position in which the body is held is not in any case so prolonged as to cause fear of injurious consequence or any permanent deformity.

(5) Noise. — This is closely related to pressure of air, but the degree of discomfort varies noticeably according to whether the work is done in the open air or in enclosed spaces, and also according to the size of the latter. There must also be taken into account the kind of material to which the blows are applied (riveting sheet iron). Closing the external meatus of the ear with plugs of cotton wool, indiarubber or wax, etc., prevents not only damage to the hearing apparatus but especially the injurious influence which the noise exercises on the nervous system. All the tools should necessarily be provided with a valve capable of stopping the entrance of air into the valve box which emits the noise when the tool is not at work.

(6) Dust. — In addition to the effects described and as a factor in increasing signs of fatigue, the danger from the dust given off in the course of work should be mentioned, as the quantity so produced is always greater than that given off in hand work, because it is obviously proportional to the speed at which work is done.

The harmfulness of this dust is increased by several factors (work on stone, work in confined spaces) quite independently of its physical or chemical qualities.

These inconveniences can be diminished or avoided by using hollow drills allowing a jet of water under pressure to be directed, at the same time, on to the spot where the drill works; this has two advantages, softening the rock and total suppression of the dust, as this is at once reduced to a state of paste by the water.

This arrangement of a jet of water, however, is only applicable with hammers of considerable weight and volume. In other cases, the raising of dust can be largely avoided by moistening the materials, if this can be done without damaging them. In all other cases, the usual methods of prevention must be adopted, e.g. respirators, goggles, etc.

LEGISLATION

Compensation for diseases of the muscles, bones and joints due to work with compressed air tools (drills, hammers, pneumatic riveting machinery, etc.) is provided in Germany (1929) and Czecho-Slovakia (1932).

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Communication from Sir Thomas LEGGE to the International Labour Office (cases studied by Dr. MIDDLETON, Medical Inspector of Factories).

The photographs are reproduced by courtesy of Prof. G. LORIGA.

Prof. G. Loriga
(Rome).
Podophyllin


Podophyllin is a resinous substance containing active principles of Podophyllum peltatum Linn. It is prepared by subjecting to alcoholic extraction the powder obtained from the rhizoma of podophyllin. The extract, after being reduced to a third by means of distillation, is poured drop by drop into a large quantity of water containing 1.5 per cent. of hydrochloric acid; the precipitate obtained is washed, dried at a low temperature and pulverised.

Podophyllin is an amorphous powder of a brownish or greenish yellow colour, with a slight 'odour' and a sharp and bitter taste. Insoluble in water, it is soluble in alcohol and slightly so in ether and chloroform. It contains podophyllotoxin, picropodicphyllin, podophyllin, etc., as well as a colouring substance which seems to be identical with quercetin. Podophyllin is a resinous substance identical with quercetin.

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Podophyllin is used as a medicament.

In contact with the eye, podophyllin gives rise to intense conjunctival hyperaemia, with lachrymation, but without increased mucous secretion. At times there is oedema, red spots on the eyelids which resemble papulae and a burning sensation of the eyes. In general symptoms affecting the cornea and iris are the most prominent features of the clinical picture. In the cornea there occur opacities which are barely perceptible. In other cases, on the contrary, there is a central opalescent whitish infiltration with superficial erosion of the epithelium. The characteristic symptom is constituted by irritis, which supervenes rapidly and violently, attaining its maximum evolution by provoking exudation in the anterior chamber, considerable diminution of sight and intense superorbital pains. This symptom complex ceases rapidly, however, and if the patient is removed from the action of podophyllin the affection generally clears up in eight to twelve days.

Sureau (1902) was the first to draw attention to the harmful action of podophyllin. Rocca Serra (1902) in his thesis has described in detail lesions affecting the anterior segment of the ocular globe and has undertaken research with a view to ascertaining what are exactly the anatomo-pathological alterations caused by podophyllin. These two authors, however, do not refer to more deep-seated symptoms or injuries caused by this substance. It was Chiari (1910) who, having met with three cases of injuries of the eye of an occupational character due to podophyllin, drew attention in the most serious of these cases to the occurrence, in addition to phenomena localised in the anterior segment of the ocular globe, of a bilateral diminution of sight and an absolute scotoma of elliptical form situated quite close to the "macula lutea."

Podophyllin and its active principle podophyllotoxin are readily dissolved by tears having an alkaline reaction. They destroy the corneal epithelium and injure the nervous cells by causing lack of sensibility of the cornea. The iris, on the other hand, acts as an organ of secretion and the podophyllin exerts on it a similar action to that exerted on the intestinal glands.

Deep-seated changes in the eye are perhaps due to a slow but continued action of the irritant liquid — that is to say, of the abundant lachrymal secretion containing a relatively great quantity of the toxic substance. The latter penetrates deeply into the tissues and gives rise to phenomena in the anterior part of the uvea as well as alterations of the retina and the optic nerve — alterations which may be ascribed to poisoning of the nervous element (Oblath).

Podophyllin dust has also caused irritation of the respiratory passages, which results in a cold amongst workers engaged in the preparation of podophyllin (Koelesch, Hessburg).

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Poisonous Woods


Many processes in the wood industry (sawing, planing, boring, drilling, removal and utilisation of waste) give rise to wood dust, which is classified among the sharply-pointed dusts of moderate hardness. Every particle of this dust, according to Lehmann, would average about 10 microns in size.

Ordinary wood dust has attracted attention by reason of its purely mechanical action, but handling of certain kinds, especially woods coming from abroad,
requires still greater care because of the essential oils impregnating these which, when liberated in the dust, may affect the health of the workmen concerned.

Con structural timber of Europe or other temperate regions sometimes comes from trees (e.g. oak, beech, chestnut, and trees of the species yew and juniper) containing poisonous or injurious substances, but they are generally innocuous or contain such minute quantities of the toxic agent that very little trouble is attributable to them.

On the contrary, quite a number of foreign woods from tropical regions, much sought after because of their special qualities for coachmaking and fine cabinet making and for use in the dyeing and perfume industries, cause, according to their genus, either an irritation of the skin, mucous membranes, or symptoms of general poisoning. Although cases of dermatitis and toxic symptoms set up by foreign woods are frequent, their precise origin and a probable cause have not been accurately determined. Some reports even contain definite statements as to the impossibility of obtaining precise information as to the kind of wood used. This accounts for the fact that, in the majority of cases reported, the dermatitis is attributed to satinwood without specifying or even knowing the scientific name of the special wood in question. Again, the commercial name of the wood is unfortunately too often based on the country of origin or on some special qualities for technical purposes, qualities which are to be found in kinds of wood quite different from the botanical point of view.

The numerous foreign woods capable of setting up the lesions in question all belong to trees of tropical or subtropical regions known under the following names: scented wood, iron wood, yellow wood, courbaril, lignum nephriticum, bone wood, purple or violet wood, red or Brazil wood, satinwood, teak wood, greenwood, woods from Guiana and Cayenne, e.g. cumaru wood or tonka, Dipleryx odorata (Aubl.), or Brazil, Venezuela, etc., cocoz wood or Cuban grenadil (from Inga vera (Willd.) or according to some writers from Brya ebenus D. C.). The botanical name has only been given to those woods capable of setting up toxic disturbances and enumerated in the following list:

East Indian satinwood or Indian yellow wood (Bahamas) (Bois satiné des Indes orientales = Ost-indisches Satinholz — Madura satinholz; Legnosa seba = Madera sebana) comes from Chloroxylon swietenia D. C.; West Indian satinwood coming from Fagara flava (Krug and Urban) is identical with Xanthoxylum crinatum (Spreng.) and is obtained in Jamaica, San Domingo, the Bahamas and especially from Porto Rico; Asias satinwood or satinwood from Ferrula guianensis found in Guiana and another variety from Ferrovia vartegata is obtained in the Antilles; Black ebony wood (Bois d’ébène noir — Ebenholz — Ebony; Xylocera de Bois) comes from different species of Diospyrus africanus (Madagascar, Zanzibar), or Asiatic (Mo- luccas). or, according to others, from Mauba ebenus, West Indian mahogany, from Swietenia mahagoni, and West African from Swietenia or Khaya Senegalensis; South or West African boxwood (Buis africain — Afrikanischer Buchbaum); Gonjona Kamassi comes from Sarcococ- phus Diderrichtii; Macaribo boxwood from Tabebuia pentaphylla; Rosewood comes from Rhodorhista scoparia: Magenta rosewood from Benueo; Teakwood (Bois de teck or tik — Teak Holz — Legno di teck — Madera de teca) comes from the East Indies, from Tecloa grandis (Linn); fine teak (Bassia wood) comes from Bassia longifolia or latifolia.

The Japanese wood Tagayasan, the dust of which is sulphur yellow in colour, turns violet or brown on exposure to air; Australian mohwah wood or wood of Flinders Australis: cocloba from the species Polygonaca colorata; West Indian mahogany, from the East Indies, from Tecloa grandis (Linn); fine teak (Bassia wood) comes from Bassia longifolia or latifolia.

**TOXICITY**

Comparison suggests itself between the affections due to woods and those commonly known to be set up by the leaves of the anacardiaceae (Anacar- dium occidentale L., Semecarpus venenosa (Vlks.), etc.) and notably by those of the sumachs of North America (Rhus toxicondendron L., Rhus vernicifera D. C., Rhus venenata D. C., etc.) used for making Japanese lacquer — which set up an irritation of the skin accompanied by slight fever, itching, and a sense of tension in the head and limbs. According to the researches of Scheube, the emulsion of resin of Rhus vernicifera (Japanese lacquer) has no injurious action as soon as the lacquer dries and hardens, either because the noxious ingredient evaporates or because it is modified by the oxygen of the air; the latter reason seems the more probable. The severe symptoms produced by Rhus toxicondendron which has been frequently studied, most recently by Rost and Gilg, would appear to be connected with a poisonous oil called “toxicodendrol”, the chemical properties of which somewhat resemble those of “cardol” — a substance obtained from other anacardiaceae and possessing likewise an irritating action on the skin. The chemical constitution of Khaya Senegalensis and cardol are not known; they are supposed to be compounds of glucosine. Numerous experts have tried to obtain pure chemical combinations which would set up toxic symptoms characteristic of satinwood. Harvey Gibson,
of Liverpool, and Dixon, of Cambridge, (England), are said to have extracted an active principle from Conium Ka-
massa — an alkaloid which has an action on the heart similar to curare. In 1909 Auld extracted, from satinwood, coming from Chloroxylon swietenia, an active principle which he called "chlor-
 oxyloxine". Cash, of Aberdeen, also carried out physiological experiments in 1911 with this alkaloid. In the same year, Iwakawa isolated from Japanese tagayasan a substance like chrysoarbinne, capable of setting up digestive and renal lesions. The content in this wood of the substance varied from mere traces to 0.73 per cent. In 1913 Nestler isolated from satinwood a soluble substance analogous to stearine.

According to Gilg, of the Botanical Museum at Dahlem (near Berlin), the Chlorophora excelsa (Eth. and Hook) or Morus excelsa (Welm.) is generally known under the name of "muilwood" of West Africa. Experiments with this wood were made at the Hygienic Institute of Bremen which were not published, but which do not seem to have given definite evidence as to any irritating action on the skin.

Matthes and Schreiber, in the course of their experiments on six kinds of wood from the point of view of botany, chemistry and physiology [fine teak wood from the East Indies; teak wood from Tectona grandis; wood of Flindersia Australis; Lapacho wood (which comes from one of the Bignoniaceae of South America); the wood of Tecoma araliacea (of Brazil); and green wood (of Bignonia Lewcovylyon of Surinam)], could only obtain a characteristic alkaloid in the case of Flindersia, a wood used specially in the building of ships and for sleepers on railways. The alkaloid of Flindersia, which they called "flindersin", possessed neither an irritating action on the skin nor any striking noxious properties. The resin coming from the woods mentioned had no irritating action except when it was composed of non-saturated resinous acids in a free state. But this was not the case with Flindersia, which chemically belongs to the saturated compounds. It should be added that the piece of wood examined belonged to a botanical museum and its chemical composition may have been somewhat modified by the fact that it had been exposed for a long time to the action of air.

1 This alkaloid is said to have had the formula C₁₇H₂₁O₄N. Its amount varies with different samples of wood from mere traces to 0.07 per cent.

Lastly, it should be mentioned that among the chemical compounds to be met with in a large number of woods are notably Bapachonon and Lapas-
chol. The latter, discovered by Patern-
no, of Rome, in Lapacho wood, is described as an oxyynaphthoquinone of an amylene side chain. Cross and Manuelli later extracted from the same wood lapachenon. The irritant action of these two compounds, however, when present in several kinds of woods, disappears when in the pure state.

Fortunately, the persons who handle these kinds of woods are not all attacked and only those particularly susceptible to the action of the sub-
stances, still but slightly understood, which they contain become affected. This finding recalls similar observa-
tions with regard to the action of the primulas (Primula obconica) and other ornamental plants which cause an eruption sometimes — very profuse, but limited to certain individuals — of special susceptibility (see the "Cicatrices Gardens", "Skin Diseases", etc.).

Although other experiments have not given different results, the researches of Matthes and Schreiber quoted above support the view that any injurious action on the skin of workmen caused by irritating woods is essentially due to the fact that they contain non-saturated resinous acids in a free state.

STATISTICS

The first occurrence of skin lesions from the working of exotic woods was described in 1893 by Jones, who had come across them amongst the Clyde shipyard workers, and about the same time by Sternberg among the cabinet makers of Vienna.

In 1902, Oliver, in his book Diseases of Occupation, referred to cases of dermatitis dating some years back among Edinburgh cabinet-workers using satinwood, Californian sequoia, and rosewood; while the German factory inspectors reported some cases of illness at Hamburg from "locan-
dario di Campo".

In 1902, at the meeting of the British Medical Association, Dr. T. F. Young, of Liverpool, described certain symptoms in shipyard workers from boxwood coming from Tabebua pentaphylia (of the order Bignoniaceae).

Two years later, Jones described cases due to East Indian satinwood; and during the year 17 cases from coccoloba wood were investigated at Strasbourg.

In 1905, the army surgeon Bidie described cases set up by satinwood, and W. Evans the first cases from teak. The following year the Austrian inspectors enquired into dermatitis from coccoloba, while Veysey Smith, Inspector of Factories in Norwich, studied cases set up by Borneo rosewood.
Other factory amongst several workmen in the cabins (satinwood) yards engaged especially on cabinet work in Aberdeen, also reported among cabinet makers. Cash, of several cases attributed to satinwood were Japanese of "hag " reports such cases amongst workers hand- an obstinate and painful nature. Breme inflammation of the skin — annual reports. have been regularly described from the nine factory inspectors' districts this kind in the wood-working industry. with obtaining data in relation to cases of Office (1911) charged - the factory inspectors blance to teak wood. from East Africa having a striking resem- Breslau wood. in 1912, dermatitis wood from Australia, by Indian satinwood, but was not certain as Fagera flavia wood. In 1909, cases set up by satinwood from Jamaica. The subject of this dermatitis became so hypersensitive that she suffered from inflammation of the skin even when she worked with ordinary oak. Possibly particles of injurious dust may have stuck from inflammation of the skin even when they came into play at the moment of working on a harmless wood. In 1909, cases set up by satinwood from Brazil were similarly investigated by Sieghelm. Balban (1910) described cases in Vienna attributed to satinwood and Atlas ozimatiss wood. Hagemann reports 12 cases in Breslau set up also by "moule" wood from East Africa having a striking resemblance to teak wood. A report of the German Imperial Health Office (1911) charged the factory inspectors with obtaining data in relation to cases of this kind in the wood-working industry. Numerous cases attributed to satinwood, teak, mohwah, lemon, acacia, or coccoloba from the nine factory inspectors' districts have been regularly described in their annual reports. The action is limited to inflammation of the skin — sometimes of an obstinate and painful nature. Breme reports such cases amongst workers handling "moule" and East African wood. In 1911 also Iwakawa investigated cases of dermatitis and conjunctivitis from Japanese tagayasan wood. In Berlin several cases attributed to satinwood were reported among cabinet makers. Cash, of Aberdeen, also described cases he had seen amongs workmen in naval shipyards engaged especially on cabinet work in the cabins (satinwood). Coccoloba wood set up, in 1912, dermatitis amongst several workmen in a stick factory. Nestler reported on similar cases. Other cases set up by fresh teak wood were reported in 1913 in Berlin in the Wilhelmshaven yards (Dr. John) and by E. Franck. In Italy, in 1915, Devoto had charge of cases of dermatitis in the clinic for industrial diseases in Milan. In the years following the war the number of cases diminished, whether due to the improvements in the exhaust ventilation for removing the dust or diminution in the importation of exotic woods it is impos- sible to say.

**SYMPTOMS**

The symptoms caused by the dust of these different kinds of exotic woods can be grouped as:

1. Irritation of the skin.
2. Irritation of the exposed mucous membranes.

These different manifestations cannot with certainty, in the present state of knowledge, be accurately related, either to the channel of entry into the system of the noxious substance or to the differences that exist in the sub- stances themselves. Possibly, the principal factor may be the susceptibility of the person attacked.

The local or general symptoms can present themselves either immediately following contact with the dust, or later. Generally, local lesions appear first on the uncovered part of the body, most of them on the hands, fingers, forearm and face, and more rarely on the back, trunk, etc. The skin, at first red and oedematous, can then become covered with an eruption (vesicles, papules and even pustules). Certain woods cause fairly charac- teristic lesions. Thus, Japanese taga- ayasan gives rise to a brown or even a black pigmentation analogous to the lesions pin- boiled by burns from black powder. Certain writers describe also a characteristic lesion of the hand which has been called "crocodile hand" (Horand). The rash may disappear in a few days, but may recur two or three times in succession.

All these forms of dermatitis are accompanied by intense itching.

The dermatitis due to these woods presents naturally analogies with other industrial skin maladies (eczema), long known under the name of "itch", "cancer", etc. It would therefore seem desirable that research should be engaged in with regard to them. They do not appear often except in the presence of "general debility", nutritional disturbance (natural or acquired) capable of causing
general digestive disturbance, chlorosis, etc. (Neisser).

Persons who have suffered once from a skin disease (especially from eczema) and have recovered, are probably in condition of hypersensitivity (anaphylaxis), which gives to the eczema the characteristics of a true industrial disease. Wechselmann spoke of anaphylaxis for the first time in 1909. Without going into further detail (see the article "Skin Diseases"), it should be said that the dermatitis in question belongs to the ill-defined category of eczemas and erythemas without special clinical appearances. Sometimes they can, however, take on the special characteristics connected with the causal agent as regards localisation, morphology, etc. It is further possible that in the pathogenesis of these maladies the general state of the health plays a part at least equal to the state of the digestive system and the condition peculiar to each individual.

The eyes are also often attacked — conjunctivitis with intense lacrymation, and even irido-cyclitis and somewhat severe keratitis (by tagayasan).

The affection has its seat sometimes in the nose, giving rise to frequent sneezing and considerable nasal secretion.

The sufferers complain of anorexia, nausea, roteching, palpitation, vertigo, sweating, and chills. The respiratory tract is the seat of various phenomena: retrosternal oppression, dryness of the throat, cough, difficulty in breathing, asthma, air hunger, bronchitis. These symptoms are notably provoked by African boxwood (Gonioma Kamassi) which is said to be also responsible for headache, somnolence, general malaise, and, especially, slowing of the pulse and dilation of the pupil.

To the same wood is attributed a chronic action showing itself in a yellow tint of the skin and camphor-like smell of the breath. Experiments on animals are said to have caused death with the picture of paralysis of the respiratory centres.

Without giving other examples, it must be remembered that those cited are isolated observations insufficiently controlled, not only as to the origin of the wood, but also as to its botanical identification. Whether this is right or not, the symptoms occurred, in general, on the first contact with the kinds of wood enumerated; in a minority of the cases the sensitiveness of the sufferers to the action of the woods increased remarkably on each fresh exposure. Apart from an obvious Idiosyncrasy in certain persons, there is the possibility of acclimatisation to be considered on the part of the majority of persons exposed, always excepting those afflicted with asthma and bronchitis. In some cases, finally, an obstinate resistance to treatment has been observed.

Generally the malady lasts some weeks — in a few cases as long as six.

**Hygiene**

Seeing that the noxious effect is due to wood dust, it is of the first importance to provide exhaust ventilation as near as possible to the point of origin of the dust. The different wood-working machines should have suitable covers. The ducts connected with the covers should not enter the main duct at an acute angle. All sharp angle bends in the piping must be avoided throughout the system and powerful exhausts should be applied, so as to secure rapid air currents and ensure as complete a removal of the wood dust as possible. Should it be impossible to remove the dust in this way, all wood having irritating properties should be moistened before working.

Tools soiled by the noxious dusts, it should be remembered, may convey the irritating property to otherwise innocuous dusts.

The workers should wear overalls, in good condition and fitting closely near the neck; during and after work all exposed parts of the skin should be well cleaned, and specially susceptible workers should not be employed on woods with irritant action.

**Legislation**

The effects produced by West African boxwood (Gonioma Kamassi) are brought under the Workmen's Compensation Act in Denmark, Great Britain, British Columbia, Venezuela and Minnesota (U.S.A.). A judgment of the Imperial Insurance Office in Germany since 1911-1913 regarded these morbid conditions more as industrial diseases than as accidents.

Dermatitis and ulceration of the skin due to dust and liquids are likewise compensated under British law.

**Bibliography**


Postal, Telegraphic and Telephonic Services

**Telephone**

French: Téléphone. — German: Telephon.  
Italian and Spanish: Telefono.

**Sources of Danger**

The hazards of the telephone industry fall naturally into two groups: (1) those of the outdoor employees, and (2) those of indoor office employees.

(1) **Workmen employed in the open air** and especially linemen, trench diggers and cable layers may be exposed: to burns and shocks from the electric current, owing to crossed wires; to fractures, dislocations, contusions and sprains, due to falls while employed on elevated work; and to wounds from handling copper wire which may present sharp ends.  

Outdoor employees are therefore subject to dangers of accidental injury rather than industrial diseases. Nevertheless they are liable to rheumatism and to diseases caused by cold, while men who lay cables in the ground are liable to poisoning by carbon monoxide from the escape of gas.

At Chicago in one year alone 473 cases of electric shock were reported, two of which were fatal. Layers of telegraph lines formed the majority of victims of these accidents. Statistics cited by Hoffmann based upon 205 deaths among layers of telegraph lines exhibit 48.3 per cent. as due to accident, 18.5 per cent. to tuberculosis, 6.3 per cent. to diseases of the respiratory passages, and 3.9 per cent. to diseases of the urinary system.

(2) **Indoor employees**, however, merit more detailed consideration from the medical hygienist. It is extremely important from every point of view to safeguard the health of these employees, who are for the most part young girls about the age of puberty. Moreover, a telephone girl is not a real asset to the company which employs her until she has had a year's apprenticeship. Hence the economic necessity of maintaining her in good health to lessen as far as possible the labour turnover, which is as a rule very great.

In the United States a young telephonist commences her training in the school of the company, where there is ample opportunity to observe her health and secure the correction of defects or disabilities, such as poor teeth, or diseased tonsils. The maintenance of a high hygienic standard in the workrooms, known as "centrals," is a matter of the greatest importance; and it happens to be of equal importance for keeping in good condition the delicate electric apparatus and the health of the operators. The rooms must be kept scrupulously clean, free from dust, dirt and moisture which foul the switchboards and cause short circuits; they should be warmed in the cold season, well ventilated and lighted either by natural or artificial light. Proper seating adjustments admitting of change of posture to lessen fatigue, rest and refreshment rooms, good toilet and washing facilities; and lockers are all essential factors. In smaller stations, as e.g. those in villages, in which, although they are usually important offices, night calls are infrequent, provision may be required for sleeping quarters for the attendant.
A large telephone exchange where two or three hundred young girls may simultaneously be occupied is peculiarly difficult to ventilate. In the United States high vertical switch-boards are arranged in a "U"-shape, thus cutting off currents of air.

A sanitary inspector is employed to inspect periodically conditions in all company buildings, and also to make studies, in conjunction with the chief engineer, of the ventilating conditions.

The girls are seated close together in front of the switch-boards, whilst supervisors or "monitors" occupy the centre or walk about inserting plugs and "listening in".  

Pathology

Among the female personnel the following disorders frequently occur: anaemia, loss of flesh, typical nervous conditions, sthenia, insomnia, headaches, and symptoms of hysteria.

Work in large exchanges—or "centrals"—is often such as to provoke quite rapidly among predisposed workers an incapacity for reliable and sustained work. With young girls especially the strain gives rise to general weakness, which lowers the body resistance and paves the way for tuberculosis and diseases of the respiratory passages.

The harmful factors are not only excess of work, such as a too prolonged time-table with the multiple Siemens, but also imperfect hygienic conditions at exchanges, such as ineffective ventilation, bad heating, night work, no fixed hours for meals, etc.

It must also be borne in mind that in certain cases young girls (auxiliaries) are concerned unaccustomed to sedentary work which is tiring, nerve-racking and hurried; this alteration in life certainly influences the bodily system in a general way.

Diseases attributable to occupation are rare. But it can be stated that common diseases, such as rheumatism, neuralgia, myalgia, arthritis, rheumatic fever, angina, bronchitis, acute and chronic catarrh of the bronchi, pleurisy, cephalgia, giddiness, nervous excitement, etc.—which with a normal ear disappear after a period of rest—may become dangerous for a diseased ear.

According to Politzer and others the pathology of these symptoms is easily explained by defective hearing and by the neuropathic condition of some telephonists obliged to make a sustained effort of attention to catch the sounds. Most specialists are of opinion that the healthy individual who is neither neurotic nor overworked easily becomes adapted to continued and prolonged telephone work. But if the work is excessive it may cause a general nervous condition and sometimes troubles of hearing—as when the ears do not function together causing double hearing, or strong buzzing in the ear—a diminution of hearing, or shooting pains.

Braunstein was the first to examine 160 operatives at a telephone exchange (Munich) and although he was restricted to seeing only those who submitted voluntarily to the medical enquiry, he was not able to find any injurious effect from the telephone upon healthy hearing, but was only able to prove that this work is harmful in cases of ear trouble. Mancioli, of Rome, has raised the point of troubles being due
to a slight lesion of the labyrinth rather than to a nerve condition.

Blegvad, who examined 450 operators of the Copenhagen exchange, found very often (in 26.4 per cent.) retraction of the tympanic membrane in the ears to which the receiver is applied. The other ear only showed a very slight retraction or none at all. Sixty-six persons did not hear deep tones well on account of being accustomed to them. Nevertheless he did not find any effect upon chronic diseases of the middle ear, nor any diminution of hearing amongst other operators, nor the improvement in hearing of which some boast and which is due rather to middle persons did not hear deep tones well retraction often of the Copenhagen exchange, found very to rupture of shock to etc. contact with subscribers call at the same time, or mm, 1927). easily injure telephonists' ears men. to be more closely studied by medical drawn, it 

In conclusion and generally speaking it may be said that the call upon the hearing exceeds ordinary conversation too slightly to cause serious troubles, save a slight transitory fatigue of the vestibular apparatus. While observations made up to the present only permit very general conclusions to be drawn, it is a matter which deserves to be more closely studied by medical men.

The secondary noises (defective apparatus and lines; call bells, etc.) may easily injure telephonists' ears (Solo-min, 1927).

More serious dangers are caused by electrical discharges due to lightning, storms or the current.

The discharge may occur when two subscribers call at the same time, or just as the operators touch the metal part of the plug, or their lips come in contact with the metal microphone, etc. Generally the pain is not painful. However, on one occasion this shock to the ear was the cause of rupture of the tympanic membrane (case of Bernhardt). But as a rule it only causes an attack of nerves of such a kind that most observers are of the opinion that the very large number of telephonists who are victims of such accidents are neuropaths or anaemic and that their accidents (trembling, cramps, partial paralyses, muscular weakness, diminution of visual acuteness going as far as blindness, anaesthesias, parasthesias, vaso-motor disturbances, etc.) are due for the most part to hystero-traumatic or neuro-traumatic troubles, the discharge only very rarely passing through the body of the operator.

However, Trautmann (1927) found in a telephonist after an electrical discharge pupillary troubles on one side and anomalous reflexes. As accidents due to electrical discharges may be instanced two cases of paralysis which lasted several months and five of shorter duration caused by a storm at Lyons (1931).

Recent experience has shown that these violent noises produce their harmful effect upon the labyrinth by bone conduction rather than by air conduction. As a matter of fact protecting plugs placed in the external meatus to deaden excessive sounds are not of any benefit.

On the contrary it is notorious that with perfect apparatus and a good installation of aerial lines, operators do not suffer the inconveniences produced by sharp, strident, violent or sudden sounds.

The receiver readily warms the ear causing a local sweating with itching, frequently followed by boils, or eczema and even mycosis of the external ear. Miss Richardson (United States) states that a lesion of the skin due to a mechanical irritation of the plug may be the door of entrance for local infection, exceptionally for serious eczema. The same author expresses the opinion, which is very prevalent among American telephonists, that the metallic (brass) part of the plug may cause an occupational poisoning, even penetrating the skin. She affirms that the use of acetone for cleaning the signe marked upon the multiple has caused some cases of malaise among the staff, for they dry up the traces of acetone with their fingers rather than with a cloth. Miss Richardson has also reported some cases of neuralgia localised on the shoulder blade and of abdominal pains caused by the effort necessary to put the plug in the furthest holes.

McCord reports (1931) nyctagmus, deafness in one ear and nervous and

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POSTAL, TELEGRAPHIC SERVICES
In 1919 out of 9,428 candidates 815, or 8.6 per cent., were rejected on account of physical unsuitability. Among those one-fifth were rejected on account of an unhealthy state of the respiratory passages, and 18 per cent. for insufficient development. However, at the present time a young girl, even of inferior physique, is accepted if she is considered capable of doing the work required of her. Then, in her status as an employee, an appropriate course of treatment restores her to the normal condition, that is to say, to the physical standard required for the work to be performed.

In 1919 out of 618 telephone apprentices 478 had to abandon their apprenticeship on account of bad health. There is no doubt whatever that if the telephone personnel were subjected to a very careful examination there would be fewer discharges, and the figures could be kept thus much nearer a maximum level.

Fumarola and Zanelli (1913) have also reported, among telephonists at Rome, cases of neuritis which take the form of neurasthenic hypochondria associated with anxiety, neuritis and vaso-motor troubles. The authors did not find any history of nervous affections in the families, but did find history of previous nervous trouble in the individual. They urge the necessity of a very careful medical examination on entering the service and also periodical examinations.

An enquiry made in 1923 by Dr. Trambizky regarding the health of telephonists of the towns of Kharkow enabled him to report that the variety of sounds emitted by a telephone apparatus had a definite action upon the ear, which, according to him, results in an amelioration of deafness. Even a superficial examination confirms the existence of nerve diseases which have so frequently been reported among telephonists.

G. Zerba (1925) does not consider that the sickness among telephonists and telegraphists is so negligible as is generally allowed. The figures collected in the telephone and telegraph exchanges of Karlsruhe and Heidelberg show that the female personnel is much more affected than female clerks, both from the point of view of gravity and the duration of the diseases. Although he considers it necessary to bring forward a greater wealth of evidence before drawing conclusions, he gives meanwhile the following figures (for the period 1920-1923 for Heidelberg):

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Total of persons employed</th>
<th>Number of sick</th>
<th>Number of occasions of reporting and</th>
<th>Nervous diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telephonists</td>
<td>244</td>
<td>212</td>
<td>634</td>
<td>53</td>
</tr>
<tr>
<td>Telegraphists</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persons engaged in both services</td>
<td>52</td>
<td>39</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>42</td>
<td>103</td>
<td>20</td>
</tr>
</tbody>
</table>

The mean duration of sickness for 10 cases has been from 442 days for tele-
phonomists and 467 for telegraphists, 478 for employees working for both services, whilst for the female clerical staff, it was only 70 days (local figures of sickness for Leipzig).

The International Brotherhood of Electrical Workers of the United States gives the following figures for sickness and accidents among American electricians for the period from 1922 to 1924:

<table>
<thead>
<tr>
<th>Causes</th>
<th>1922 Lines</th>
<th>Exchan-</th>
<th>Other</th>
<th>Total</th>
<th>1923 Lines</th>
<th>Exchan-</th>
<th>Other</th>
<th>Total</th>
<th>1924 Lines</th>
<th>Exchan-</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrocution</td>
<td>23</td>
<td>7</td>
<td>1</td>
<td>31</td>
<td>12</td>
<td>10</td>
<td>7</td>
<td>29</td>
<td>22</td>
<td>11</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>Falls</td>
<td>4</td>
<td>4</td>
<td></td>
<td>13</td>
<td>5</td>
<td>7</td>
<td></td>
<td>17</td>
<td>13</td>
<td>11</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>Burns</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>11</td>
<td>6</td>
<td>11</td>
<td></td>
<td>17</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Various accidents</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>11</td>
<td>6</td>
<td>11</td>
<td></td>
<td>17</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>9</td>
<td>18</td>
<td>6</td>
<td>33</td>
<td>7</td>
<td>19</td>
<td>5</td>
<td>31</td>
<td>5</td>
<td>22</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>3</td>
<td>11</td>
<td>3</td>
<td>17</td>
<td>5</td>
<td>14</td>
<td>1</td>
<td>20</td>
<td>7</td>
<td>23</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>45</td>
<td>13</td>
<td>109</td>
<td>38</td>
<td>64</td>
<td>13</td>
<td>115</td>
<td>60</td>
<td>75</td>
<td>13</td>
<td>148</td>
</tr>
</tbody>
</table>

According to L. Dublin tuberculosis and pneumonia among these workers should be considered as their most important occupational diseases.

**Prophylaxis**

The prevention of sickness among the personnel of telephone exchanges depends upon the installation of the system (wires), upon the individual, and upon the internal administration of the service.

As regards the installation, among other measures the use of fuses against high tension currents is advised; also the insulation of microphones and receivers during storms, etc.; but especially a greater use of subterranean cables in the place of aerial lines; and the use of receiving apparatus which is lighter and more efficient and which allows good aeration of the ear and an effective protection of the labyrinth.

As regards the individual, endeavour should be made to eliminate neurotic-holic persons, those predisposed to nervous diseases generally, and those who during their apprenticeship show that they do not possess the qualities necessary for the work demanded.

The psychological qualities considered necessary are the following; good hearing and eyesight; auditory memory; sense of distance; sustained attention; rapid reaction; calm disposition; smooth temper. The physician will determine the physical defects with due regard to the requirements of the occupation and its attendant risks. For the various series of tests readers are referred to special publications.

The organisation of the service should prevent troubles that arise from monotonous and tiring work. The work hours, the rest intervals, the rapid reaction; calm disposition; smooth temper. The physician will determine the physical defects with due regard to the requirements of the occupation and its attendant risks. For the various series of tests readers are referred to special publications.

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medical attention, either for consultation or for emergencies.

If the patient requires prolonged treatment she is referred to her family physician, who may avail himself of X-ray or clinical laboratory examination of the blood, urine, sputum, etc., made in the company’s laboratories.

Accidents which do not necessitate the patient lying in bed are treated on the company’s premises. One of the largest American companies has in addition to a most elaborate X-ray department, an electro-cardiograph and a completely fitted emergency operating room.

There are also special services offered to employees, such as examination of the teeth by dentists, teeth cleaning by dental hygienists and examination of the feet by chiropodists.

Employees on duty are strictly supervised by the monitors who are on the watch, and as soon as a girl shows signs of fatigue and begins to make mistakes, she is temporarily taken off duty and sent to the rest room where a trained nurse looks after her.

Certain of the companies in addition maintain homes of rest in the country.

Recently instruction in domestic hygiene and care of the sick has been instituted and offered to women employees by the staff of the medical department. The doctors like all the employees to pass a medical examination each year; final physical examinations are made for disability, retirement and pensions.

The aim of medical service in the United States is especially directed towards the prevention of disease by means of propaganda work which endeavours to reach the employees in all sorts of ways: articles in the most widely read papers, posters, short talks, etc.

As regards other countries we may mention that in France the personnel of the P.T.T. is recruited by the Government, after an examination made by a medical committee who vigorously exclude tuberculous and suspected cases, also persons whose sight and hearing do not satisfy certain conditions. Weakly candidates and doubtful cases are adjourned for three months, six months or a year. On the other hand, no woman is passed for the town telephone service after the age of 30 years.

The fight against tuberculosis among the personnel of the postal services is to be waged chiefly by improvement of hygienic conditions in the workrooms, and the assistance measures provided for in the Finance Act of 1923 supplemented by the Decrees of 1923 and 1930. These questions come within the competence of a Superior Health Council attached to the Ministry of Posts, Telegraphs and Telephones (1929).

In Great Britain, according to a recent report (1923), certain English companies admit young girls of from 16 to 19 years to a first apprenticeship after a very strict medical examination. The apprenticeship lasts at least four weeks and is with pay. When a telephonist enters on duty she signs an agreement which provides for gratuitous treatment in hospital, dental treatment and, should necessity arise, a visit to a convalescent home. Telephonists enjoy an annual leave of fifteen days during the first five years and of 21 days after that. Spacious and airy dining rooms, rest rooms and playing fields, etc., are provided.

**Telegraph, Marine Cable, Field Telegraph, and Wireless Telegraph Services**


**Sources of Danger — Pathology**

The dangers which can be actually attributed to these occupations are not numerous. Among telegraph operators cramp of the hand is still occasionally reported — the cramp of telegraphists or users of morse instruments.

According to an enquiry made in 1922 by the International Labour Office in Germany, Austria, the United States, France, Italy, Holland and Switzerland, it seems that this neurosis of telegraphists is now a mild and a fairly rare disease, and that this is due to the disappearance of the morse apparatus, which has been replaced by more modern types (Hugues, Baudot). This disease is still seen in those countries where the apparatus in question is used.

In its report on telegraphists' cramp the Industrial Fatigue Research Board (1927) stresses the importance of the individual's constitution. Subjects who show psychoneurotic symptoms and insufficient muscular co-ordination tend to suffer from cramp. Contributory causes are the nature of the work, its monotony, speed, etc.
According to Lehmann, more than 5 per cent. of telegraphists become affected with weakness of memory, their occupation causing mental fatigue.

An enquiry made in 1907 by Rossoni and Zevi among the personnel of the telegraph service in Italy shows that a large number of troubles and diseases were associated with defective hygienic conditions of the offices. They drew attention to many infectious diseases, with tuberculosis and influenza at the top, and to diseases of rheumatic origin; to gastro-intestinal diseases; to diseases of the nervous system presenting the typical pathology for this category of workers, in the causation of which overstrain, fear of responsibility, dread of penalties, and night work are the principal factors; to nutritional diseases (anaemia, menstrual troubles among women and especially young girls); to affection of the eyes and ears due to bad lighting, noise, dust, etc.

Ssalt'ykovskij (1925) reported three cases of nervous exhaustion in telegraphists (Wheatstone apparatus).

The apprentices are moreover in poor condition of health, for they carry out all their work in very bad hygienic conditions. Work carried out in the interior offices by the apprentices, of whom the age varies from 12 to 16 years, is often the cause of anaemia, hernia, enlarged glands, cramps in the calves of the legs and synovitis in the joints, etc.

Telegraph and radio-telegraph messengers, who are often obliged to hurry, are particularly exposed to accidents such as falls from cycles, collisions with vehicles, etc., and also to diseases caused by exposure to cold, hernia, etc. Further, the men who erect the poles and put up the wires are similarly exposed to shocks or burns by contact with wires charged with high-tension currents.

Gilman Thompson quotes the case of a lineman who was electrocuted while repairing the line. But such accidents cannot be considered as peculiar to this branch of industry. The telegraph industry compared with others in reality only shows a slight number of dangers and no serious disease.

Telegrams for transmission by submarine cable are sent upon a ribbon moving at a rapid rate, similar to the tape machines used in the Stock Exchanges. The ribbon passes across the front of a typewriter so as to allow the operator to take down the messages as they arrive. This work requires very sustained attention, quick work, and is a cause of slight eyestrain. But it is easy to avoid these inconveniences by arranging a few moments of rest during the work and providing the operator with suitable illumination.

Field Telegraphy

Symptoms which can be attributed to eyestrain have been reported by Trombeta and Santa Maria (1908) among engineer soldiers employed in field telegraphy. The flashing light has a harmful effect on different parts of the eye and particularly on accommodation and the retinal adaptation. In the first stage are noticed symptoms of over-action of the accommodation, spasm of the ciliary muscle with myopia, caused by spasm of the accommodation; in the second stage are noticed symptoms of paralysis of the accommodation with asthenopia, etc. The subjective transitory symptoms are generally very slight and consist of conjunctival hyperaemia, lachrymation and photophobia. Symptoms arising from the accommodation or the retina are more serious: visual fatigue, slight distortion of colours, sometimes with a scintillating scotoma. The use of spectacles modifies the action of the flashing light upon the retina, but does not prevent the troubles of accommodation. Army signallers should not be employed at their work for too long a period, especially if there are neuro-pathic signs, and the white light used for the signals should be replaced by a coloured one.

Wireless Telegraphy

The crackling which is produced during the transmission of messages by wireless does not seem to be a source of trouble to the operator. On the contrary, operators employed on the receipt of messages are exposed to the same troubles as those which affect telephonists. The sounds received are short, piercing and strong, or very high and musical; these last are the only ones capable of being transcribed.

The speed of reception is proportionate to the speed of transmission, and fatigue makes itself felt all the sooner if the reception is very rapid. It is well known that wireless transmission is carried on better at night; but that causes more exacting work and serious strain among the operators. The messages from some countries are

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1 In Great Britain some cases of mercurialism have been noticed among workmen employed in the construction of wireless apparatus owing to the use of a salt of mercury.
sent without interruption, those from other countries on the other hand are interrupted by regular interpolated pauses in the transmission.

The operators consider that the formation of ozone in their office makes breathing difficult, which is also accentuated by the action of a particular dust which forms during transmission and is scattered in the surrounding air. Certain conditions favour the formation of ozone, e.g., stormy weather, strong evaporation, and special types of sending apparatus. Nevertheless it is opportune to bear in mind that operators complain of troubles, such as vertigo and fainting, which cannot be attributed to the action of ozone.

It is probable that the cause is another substance which according to certain authors is an oxide of copper, formed in the interior of the apparatus and deposited on the surface in the form of a dust. But it is necessary to remember that symptoms of copper poisoning have never been found among operators. Others consider that in certain conditions of work oxides of nitrogen are formed, without being able to determine exactly their rôle in the pathogenesis of the troubles which have been noticed.

It is much more probable that the cause of the trouble is simply due to the injurious action of confined air. That is especially the case with ship operators. Conjunctivitis, keratitis, and recurrent eczemas have also been noticed, and among army wireless operators palpitations so serious as to necessitate discharge.

Out of 23 wireless operators examined in Russia by Kachkadamow (1923) from a medical standpoint, only two made no complaint regarding the state of their health; 18 complained of a feeling of heaviness in the head, faintness, apathy, somnolence, and inattention; 7 complained of troubles of hearing. The greater part of the operators were from 20 to 30 years of age (87 per cent. of those examined) of whom 15 had from 3 to 7 years' service.

Voss recalls that a German sailor developed a lesion of the cochlea, the origin of which has not yet been thoroughly elucidated.

Axmann reported (in 1924) some cases of falling of the hair, localised to the side which was exposed for some months to the light from the wireless valves. He considers that the valve acts as a Roentgen tube of small power.

Jellinek has recently (1925) drawn the attention of scientists and the public to the dangers of wireless receiving apparatus. He gives quite a series of measures which should be adopted to prevent as far as possible accidents which without any doubt are fairly serious.

The percentage ratio of days of sickness to days of work has been calculated to be 2.6-6.4 for medium-grade officials, 3.3-8.5 for subordinate employees, and 4.5-0.3 for women employees.

Prophylaxis

Merschetzky suggests the following measures: exclusion of persons of less than 18 years of age; medical examination on admission and periodically, at least every six months; both ears to be used at work; special supervision of operatives troubled with anaemia or nerve conditions; exclusion of every individual suffering from, or who has suffered from, middle ear disease, even if the other ear is normal; careful supervision of unhealthy conditions of the nose and throat; a maximum of 4 hours' work by day and 3 hours' by night; pauses of half an hour every two hours during day work and every hour and a half during night work; annual leave of 50 days taken if possible in several periods.

The application of ordinary rules of hygiene such as have been already mentioned, in connection with the telephone industry is essential for this group of employees, equally for those employed in inside work as for those employed on outside work.

The medical officer should closely follow the proportion of employees away from duty on account of accidents and take steps to find out the cause in each particular case. He should test the visual and aural acuity as well as the response to tests of the eye and ear, which have a direct connection with the state of the general health.

In telegraph stations situated in the southern and tropical regions, very particular attention should be given not only to the housing, workrooms and the feeding of the staff, but also to protection against infectious diseases and parasites. Thus for example, the All America Cables, Inc., require a very thorough medical examination as well as vaccination against smallpox, typhoid paratyphoid and typhus.

By means of these methods of prophylaxis "although this system extends to regions considered at present very unhealthy, the standard of health has been maintained at a very high level".
LEGISLATION

As regards compensation for telegraphists suffering from cramp, in the majority of cases they are transferred to work on different apparatus or are given other duties in the same department. That is so in Germany where, in addition to the telegraph department, affected persons who become affected with cramp are discharged directly they show symptoms of cramp; in Austria where the personnel is changed on the first signs of the affection; in France where it is still maintained that the affection is so mild that no difficulty has ever arisen from it; in Italy, and Holland where by agreement with the directorate of the telegraph department it is possible for certain cases so affected to be transferred to other duties; in Switzerland they are employed in administrative duties in the postal and telegraph departments as well as on the railways.

Compensation

Telegraphists' cramp is compensated by the state as an industrial disease in the following countries:

Austria. — It may entitle the victim to a pension in accordance with the operation of section 62 of the Labour Charter (Dienstpragmatik of 25 January 1914) and the regulations which lay down the manner of calculating the pension.

Italy. — By virtue of section 2 of the Code of Pensions Law which are peculiar to Italy (21 February 1896, No. 70), it is laid down that a person unfit for duty on account of injuries or disease contracted in the performance of duties has the right to retire on pension whatever may be his age and length of service. Nevertheless, according to information issued by the Ministry of the Postal and Telegraph Services, during the last five years none of the employees have been put on the retired list on account of telegraphists' cramp.

Switzerland. — Employees transferred into the railway services continue if possible to draw corresponding wages in their new employment; but in case of wage reduction every facility is allowed to ensure the deficiency being made up by the Pension Office, unless the employees should prefer to be given a partial pension calculated according to the part of the wages they have lost and the years of service at the time of their transfer. Where it is not possible to transfer these persons to different duties, they are treated in the same manner as a totally incapacitated person.

In the above-mentioned countries telegraphists' cramp is not regarded as an occupational disease.

It must, however, be notified compulsorily in Holland; and is a ground for compensation in Great Britain, Western Australia, Russia, and Japan.

In the United States telegraphists' cramp is not compensated in the following States: New York, Ohio, Illinois, Minne- sota, and no compensation is provided for by the laws at present in force. The laws of eight States including California, Connecticut, Hawaii, Massachusetts, Minnesota, Dakota, Porto Rico, and the Federal Government, as regards its employees, cover industrial diseases generally, either by naming them specifically or by defining the term, and telegraphists' cramp can be compensated by virtue of these laws.

The laws of 34 other States of the Confederation compensate only industrial accidents, and telegraphists' cramp is therefore not theoretically covered by these laws. Yet the interpretation of the word "accident" as an occurrence that could not be foreseen, dating back to a definite point in time and place, has caused some cases of industrial disease to be compensated as accidents when the date of onset of the disease can be attributed to a definite point in time and place. It is a matter of law and interpretation of the law.

On the other hand the constitution of the United States provides that matters affecting trade between States are not under the jurisdiction of those particular States but that of the Federal Government. Telegraphists certainly fall into the class of workers called "inter-State." Although there is not a Federal law of compensation, except for Government employees, there is a Federal Employers' Liability Act covering transport workers on railways between the States when employed on trade between States. The only step required to be undertaken by telegraphists who are employed on railways between States is to bring an action against their employers by virtue of the Federal Employers' Liability Act, which gives them favourable modifications of the existing regulations.

As regards trade re-education, the Federal Government in 1920 passed a law allocating certain credits to the States which could make up the sums necessary to provide the re-education of those persons who have been invalided either in trade or otherwise. Twenty-six States have accepted this offer, and it can be asserted that in those States a person suffering from telegraphists' cramp will receive the necessary re-education if he requests it in accordance with the regulations laid down. The question of the residence of the telegraphist and not the question of the "inter-State" nature of his work would be important at the time of his request.

Postal Service


The postal service does not involve a type of occupational disease different from that met with in analogous occupations.

The eyesight suffers a severe strain during the sorting of letters, particularly where this is done on the rail-
ways where the illumination is subject to frequent changes and where the jolting is severe.

The rural delivery service in remote regions is carried on under trying conditions, due chiefly to climate, with exposure to extreme degrees of heat, cold, and to falls of snow.

During work in the offices a considerable quantity of dust rises from handling large mail sacks especially after a long railway journey. Tuberculosis especially is very prevalent among office employees who work in bad hygienic conditions. Gilman Thompson has noted one or two cases of slight curvature of the spine produced by carrying, through periods of many years, heavy post sacks suspended by straps from one or other of the shoulders. Flat feet are also quite common among mail carriers. Postmen who have long journeys to make on foot in all weathers suffer the consequences of excess of fatigue and continual exposure to inclement weather. Neuritis of the hand has been noticed following on stamping letters. Men employed in the recently organised aerial post are subject to accidents common to all aviators but otherwise there is no specific hazard for them in connection with thus transporting mail.

Eisenstadt has reported that the most prevalent diseases among postal employees are those of the nervous system, the heart, and tuberculosis. Alcohol and venereal diseases in addition increase the risks of this occupation. Fatigue caused by sorting and the hunting out of addresses, bad hygienic conditions in the sorting rooms, irregular meal times, etc., evidently present conditions prejudicial to health, which cannot be overlooked.

Prophylaxis

In 1922 the employees of the postal service of the United States numbered 325,000. Medical examination on admission to the service is conducted by the Civil Service Commission. These examinations vary according to the class of employee; they are more severe for rural postmen and those employed in aerial services; for these last the medical examination requires physical fitness equal to that of military aviators. For admission to the postal services as mail carriers, the height should not be less than 5 feet 4 inches and the applicant should weigh no less than 135 lbs. with bare feet and ordinary clothes.

Medical examination has up to the present only been carried out upon selected groups; it is done gratuitously. Among the employees the most frequently observed causes of disability are flat feet, varicose veins, spinal curvature, hernia, glaucoma, tuberculosis, digestive troubles, etc. Medical examinations affecting discharges on account of disability, or for the assessment of pensions, are conducted by the United States Public Health Service.

In the United States Post Office a report was issued in 1922 of a careful study of the eye conditions of 4,785 postal employees in relation to the lighting of post offices, and many interesting facts were observed. It was found that the percentage of eye defects among workers was considerable, and that it bore quite a definite relation to such factors as glare, shadows, poor spacing and irregularity of lights, etc. As the work of the employees involves reading addresses, hunting for insufficient addresses in directories, puzzling out obscure handwritings, keeping accounts, etc., it is most important that this work should be done under the best conditions of lighting and as far as possible by daylight.

It was found that variations in the colours of the envelopes and inks add considerably to the visual difficulties, often straining the eyes and handicapping the worker. In the money order and registry departments, blue and red cards and blanks are used, which were found tiring to the eyes. The so-called "window envelope" (transparent envelopes) and glazed surfaced envelopes add to the difficulties of quick reading, requiring great concentration of vision. Gilman Thompson is acquainted with a postal clerk, a coloured woman, who recently in a speed contest sorted 30,000 letters in eight hours. While this of course was a maximum rate, it nevertheless gives some idea of the possibilities of eye strain among letter sorters, especially when speeding up in the holiday season, or on account of a delayed mail.

A later enquiry (1928) has shown that the improvement in lighting resulted in an increase in efficiency (especially in speed of sorting).

The following are the more important recommendations made by the Post Office Department as a result of this intensive study:

(1) There should be installed in the general workrooms and offices systems of totally enclosed units of the diffusing or light-directing type, giving a general intensity, when first installed,
of ten foot-candles approximately on a horizontal working plane 45 inches above the floor.

(2) All local lighting should be done away with.

(3) Wire screening at the backs of sorting cases should not be used on account of its effect upon the eyes, but should be replaced by two-inch wide wooden strips.

(4) New, post offices should be so constructed that during the daytime hours the maximum amount of work possible may be done under natural illumination.

(5) Post office blanks should be of a mat surface and light buff colour with characters printed in black.

(6) The eyes of employees should be examined once a year and any visual defects corrected.

(7) The relation of the separation cases, tables and desks to the lights should be such that no shadows fall on the working plane.

(8) To obtain the recommended intensity of illumination of ten foot-candles on the working planes, it would be necessary to use about two watts per square foot of floor area in the general workroom of the post office, the best spacing and mounting of these lamps depending upon the height of the ceiling and of the working plane.

(9) Care of the lighting should be placed in the hands of one man who should be responsible for the upkeep and care of units, cleaning them at least once a week and making measurements once a month with a foot-candle meter in order to see that the uniformity and constancy of illumination are maintained.

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Dr. Gilman Thompson
(New York).

Potassium


Potassium (symbol K) is very abundant in nature, its salts being found in vegetables, in sea-water, in rivers, etc. Potassium in a free state was obtained by Davy in 1807 by decomposing caustic potash by means of a powerful electric current. Industrially, it is obtained by methods similar to those utilised for the production of sodium (see article "Sodium and its Compounds").

It is sometimes manufactured from the tartrate which is brought to white heat in an iron retort. The potassium fumes are condensed in receptacles containing petrol which preserves the potassium from oxidation by contact with air. During the reaction there is also formed oxycarbide of potassium, which is explosive.

At the present time potassium is prepared industrially by an electrolytic method starting with the chloride.

Potassium is a metal which melts when not in contact with air. It has a silver aspect, is soft at an ordinary temperature, melts at 580° C. and evaporates at 720° C. with the production of greenish fumes. Potassium combines very readily with oxygen, resulting in the production of the oxide which together with water forms a hydrate. It is well known that a piece of potassium placed in water decomposes immediately, giving off hydrogen and great heat, with the result that the potassium at the surface of the water melts and burns simultaneously with the hydrogen.
Most of the salts of potassium are at present prepared with crude salts from the saline deposits of Alsace (Stassfurt salts), Spain, Chile, etc. A small quantity is also extracted from the washing water after washing dirty wool, from the residues of alcoholic fermentation of beetroot molasses and from marine algae, etc.

In the Stassfurt deposits below the bed of rock salt there are found beds of carnallite, which is a double chloride of magnesium and potassium, of sylvite, schonite, etc.

From the point of view of hygiene it is of interest to recall that one of the most serious problems in the Stassfurt district arises from the evacuation of waste waters rich in Mg.Cl., which, when discharged into streams, ditches, etc., have finally filtered through the soil, to a great distance, contaminating well-water sources of drinking water, spoiling fishing and interfering with the watering of cattle.

Rosenthal (1910) and later Wigand have studied the influence of climate in potassium mines on the health of workers.

Amongst other compounds of potassium may be recalled:

- The hydrate or caustic potash (KOH) prepared by adding to a boiling dilute solution of carbonate of potassium hydrate of calcium, or electrolytically, starting with potassium chloride. Combining readily with water, deliquescent on exposure to air, it has, in aqueous solution, a strongly alkaline reaction and easily causes saponification. It is employed in soap making, in glassworks and in the dyeing and washing of wools, etc.

- The chloride (KCl.) is found in abundance in the Stassfurt deposits (sylvite) or in the carnallite, together with magnesium chloride. It is used as a manure, for the preparation of other salts, in the electrolytic manufacture of caustic potash and potassium nitrate (conversion method), etc.

- Iodide (see article “Iodine”).

- The chlorate (KClO₃) is at the present time prepared electrolytically, starting with the chloride or directly from the carnallite (in Germany). The chlorate is an oxidising agent utilised in the following branches of manufacture: black gunpowder, Swedish matches, fireworks, etc. in dyeworks, for oxidising certain substances in the production of aniline black. It is currently replaced by sodium chlorate, which is less expensive (see article “Chlorates”).

The nitrate (KNO₃), or nitre, comes from the East Indies and especially from Ceylon. It is utilised in the manufacture of explosives because it does not contain perchlorates. It is likewise used as a manure.

In India the soil containing the nitrate is washed with water and then left to evaporate in vats which are heated in large boilers. The crystals of crystals which form on the surface of the liquid are then separated. These crystals, consisting of potassium nitrates, magnesium, sodium chlorides, potassium, potassium sulphate, are treated in special factories with hot saturated solutions of sodium chloride and sulphate. In this manner the potassium nitrate only passes into solution and is separated almost in a pure state simply by cooling. It is refined with nitre by boiling it with the mother liquors and filtered in a hot state under pressure. The filtered liquid is then left to cool and the nitrate becomes separated out in fine crystals. It is centrifuged and the mother liquors are re-utilised.

The sulphate (K₂SO₄) is used as manure, in the manufacture of alum, of glass, and of carbonate of potassium, etc.

- The carbonate (K₂CO₃), or potash, is obtained in large quantities from wood ash, ash of plants and residue from manipulation of beetroot, or by the Leblanc method starting with the chloride or sulphate of potassium. It is used in soap making, in glassworks and in the dyeing and washing of wools, etc.

- See also articles “Alkalis”, “Chromium and Chromates”, “Cyanogen and its Compounds” and “Sodium and its Compounds”.

**Sources of Risk**

In addition to the injuries common to all underground work, mining is a source of cutaneous lesions (dermatitis), liver troubles and, if the gangue contains silica, respiratory lesions (silicosis).

If the work is dusty the presence of more than 1 per cent. of potassium nitrate in the ore leads to anaemia, headaches and in the long run organic debility and nephritis. If the workers absorb the nitrate they show a heavy loss of chlorides (examination of urine).

Medical literature contains particulars of several cases of explosion which have been caused—chiefly in chemical
laboratories — by potassium. In one case explosion was due to a potassium-bromoform mixture. The explosion occurred during distillation owing to ignorance of the fact that organic chlorides in contact with alkaline metals give rise to explosion. In another instance the explosion was due to a molten potassium-sodium alloy. In this instance, also, the explosion was a very serious one. Storing of this mixture calls for precautions similar to those to be taken in the case of phosphorus. In a third instance, potassium had been mixed with pentachlorethane. Slight percussion is necessary to cause an explosion. Violent percussion, on the contrary, merely provokes slight explosion, or even no explosion at all. In other cases, mixtures of potassium and oxalylchloride or potassium and benzene (explosion in this case being due to the formation of peroxide by auto-oxidation) were to blame.

Potassium has a caustic action on the skin.

Electrolytic production of potassium compounds causes dermatitis: Oppenheim has observed twenty-six cases in the electrolytic manufacture of potassium chlorate.

Antimonide of potassium has given rise to explosion merely by the simple action of breathing on the part of the person examining it. The explosion resulted in burns of the eyes and face (Regnault).

The hydrate of potassium causes chemical burning of the skin and mucous membranes. Its solvent action on albumin, its capacity for saponification when mixed with fat substances and its ready combination with the water in the tissues explain its action being more caustic and deep-seated than that of the acids and also constitutes the reason why ulcers caused by it heal with difficulty and leave extensive scars. Dermatitis is localised chiefly on the backs of the hands, the forearms, the face and ears. When clothing is soaked in the lye the injury may, however, attack any part of the body.

The carbonate possesses a slighter irritant action than the hydrate, but it aggravates injuries caused by other substances. There are records of injuries due to solutions of carbonate of potash and soda in the wool industry (washing) during mordanting, in woodworking (polishing with carbonates and bichromate), etc. These injuries were generally forms of dermatitis.

The preparation of permanganate of potassium by starting with pyrolusite is said to have been the cause of a clinical picture recalling that of encephalitis lethargica (von Jaksch), which Strumpell describes as "an amyostatic complex". Ocular injuries, sometimes with serious sequelae, have been described by Cords, Kassner, etc. Potassium chloride is, to be regarded as a cause of anaphylactic shock rather than of occupational poisoning. From the toxicological point of view, it constitutes a blood poison. It forms methaemoglobin and sets up very serious forms of jaundice followed by anuria and coma.

For chlorates see that article. The salts of potassium possess a real but not very violent toxic action; even when they are not combined with a toxic acid (cyanides, arsenates, etc.). They are more especially muscular poisons. This toxic property must not however be exaggerated (Kohn-Abres). Frouin and Monté (1907) have studied the action of salts of potassium experimentally. They found that they caused renal sclerosis, hepatic cirrhosis with ascites, etc.

For hygiene, see articles "Alkalis", "Chlorates", etc. As regards legislation, under Argentine and French law women are excluded from the manufacture of potassium and salts of potassium. French legislation also prescribes their exclusion from the manufacture of potassium hypochlorite. In Belgium, young persons under sixteen years of age may not be employed in the manufacture of javel water. In Italy, boys under fifteen and women under twenty-one are excluded from employment in the manufacture of potash and salts of potassium.

Compensation for injuries due to potassium compounds is provided in Bulgaria (alkalis); Switzerland (alkalis, potassium chlorate); Japan under a general formula "harmful or toxic substances"; and likewise in countries which provide compensation for forms of dermatitis due to dusts and liquids. See the various articles, "Alkalis", "Chlorates", "Sodium and its Compounds", etc.; also "Occupational Diseases: Definition and Compensation".

BIBLIOGRAPHY


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Pottery Industry


"Pottery" is a wide term, including any article made of clay (or a mixture of clay and other substances) and hardened by fire, glazed or otherwise. All common articles, such as tiles, drain pipes, bricks, crockery, etc., are thus included.

In the manufacture of pottery there are two component parts: (1) a porous substance known as the "body", which may be made either of clay unmixcd with other ingredients, or composed of several, such as Cornish stone, china clay, combined, in the case of British china, with calcined felspar, generally containing some foreign matter. These distinct kinds of clay exist, primary and secondary — the former being derived from pure felspar, called kaolin or china clay, and the latter, if derived from pure felspar, generally containing some foreign matter. In the secondary clay, the sharp edges have been worn off and it has acquired the property of plasticity. These secondary clays are called "ball clays".

Manufacture of Earthenware and China


Technical Data

After the clays have been weathered, the raw materials of the "body" are ground up, mixed in a wet state and afterwards put through a filter press, from which they emerge in cakes or lumps. Water is, as a rule, added prior to grinding, so that the process is a wet one.

The lumps of clay must be freed from air bubbles, and this is effected by mechanical treatment in a pug-mill and by a manual process known as "wedging" when which is necessary. The clays are next carried to the benches in the potters' shops, where it is moulded. Various processes incidental to this are carried on, such as "throwing", that is, shaping the clay by hand while it revolves on the potters' wheel; "turning", that is, finishing the newly moulded article by turning on a lathe, and "pressing", as, for instance, hollow-ware pressing — articles such as jugs, ewers, etc. — by pressing into moulds, or flat pressing, shaping similarly dishes, plates, saucers, etc.

After being shaped, the clay articles, with their appropriate moulds, are set aside to dry, either on racks in the general workroom, or in chambers artificially heated by a coal stove, or by a battery of steam pipes, known as "drying" stoves. When the articles are sufficiently dry, they are detached from the moulds and placed on long boards which are carried on the shoulder to the next department. After moulding, the clay article is "fettled", that is, trimmed and finished.

"Towing of earthenware" is a special process of fettling applied to earthenware, each article being placed on a mechanically driven jigger (i.e. a vertical spindle, driven by mechanical power, on the end of which is fixed a mould, revolving rapidly in a horizontal plane), while a piece of material, such as tow, placed against the article, smooths it; much dust is haled in this operation, were there no locally applied exhaust ventilation.

"Biscuit placing" is the next process, i.e. placing the moulded and fettled articles in fire clay boxes or "saggers". In order to prevent the articles buckling, they are embedded in sand, and, in the case of china, in powdered flint. Exposure to the dust from powdered flint will set up silicosis, and this embedding in flint of flat china ware is the most dangerous dusty process in the industry. After setting and firing, the biscuit oven is drawn, during which there may be exposure to excessive heat. After withdrawal, the sand and dried flint adhering to the articles have to be removed. This can be done crudely by knocking or brushing, in which processes a certain amount of flinty dust will be given off, for which locally applied exhaust ventilation is essential. Nowadays
the danger from this source has been minimised in the case of china by placing the articles to be cleaned or scoured in racks inside a drum, together with a small quantity of bits of broken ware which, when they move as the drum revolves, clean the articles by friction. The axle of the runner is connected with an exhaust fan.

For manufacture of tiles, see page 716.

Glaze process. — The glaze is sometimes ready prepared or stored for pottery in casks. When a "charge" of glaze is required, a quantity of the lead compound is weighed out and mixed with the necessary silicates and silico-borates. When a raw lead glaze is used, the operation is carried out in the lead house, where the mixed materials are ground in a wet state. The articles are then dipped into the creamy mixture. Any ingredients soluble in water, e.g., borax, must be "fritted," i.e. fused with some of the siliceous matter, to form a crude glass, before they are ground and added to the other materials. In many cases, the lead compound is introduced into the frit; if the proportion of silica to lead in such a frit is high enough, a lead silicate is formed which is sparingly soluble in dilute acids and is very much less dangerous to health than the raw lead compounds used in glazes in which the borax and similar ingredients only are fritted.

Biscuit ware is almost invariably dipped by hand, and, after removing it, the worker gives his wrist a turn to get rid of excessive glaze. Each dipper has one or more assistants — those handing the ware to him being called the "putters up" and those taking the ware from him the "takers off." After dipping, the pieces of pottery are placed on boards to dry; the cleanliness of these boards is important. In large factories the dipped ware is placed on the shelves of an apparatus known as a "mangle" — a series of shelves attached to an endless chain which moves slowly through a heated chamber. Many articles as soon as they are dipped are ready for the glost oven, where the glaze is converted into a glassy coating, but, before they are fired, they are "ware cleaned," i.e., inequalities in a layer of glaze are removed, superfluous "glaze" is removed from the bases, etc., and the risk run by the workers so engaged, most of whom are women, would be considerable in the absence of local exhaust, except where the whole of the ware cleaning is done by such moist methods as will entirely prevent the evolution of dust.

"Glost placing," i.e., placing the ware in saggers and removing it into the glost oven, is usually done by men. Subsidiary operations are the arrangement of the thimbles, stilts and spurs, which have to be inserted and removed to prevent one piece of ware becoming attached to another. From the glost oven the ware goes to the glost warehouse, where the articles are sorted or polished.

Of the decorative processes, those carried out on the clay or biscuit involve, as a rule, no use of lead whatever. By far the most important of these is the printing process on biscuit earthenware; the design is engraved on a copper plate or roller and the desired colour, mixed in an oily medium, is worked into the engraving, from which a print is then taken on tissue paper; this is applied to the ware and rubbed on; the paper is then washed off leaving the colour behind adhering to the biscuit ware, which is then generally fired in a muffle-kiln (called hardening-on kiln) to drive out the oil, etc.

Glazes in which the pigments are mixed are known as majolica glazes; these generally contain a high proportion of raw lead and should therefore be handled with special care.

On-glaze decoration involves the use of enamel colours which usually contain a freely soluble lead flux. Ordinary painting with enamel colours, in an oily medium, involves no special risk; but where these enamels are blown on to the ware (aerographing) or applied in powder form to a previously oiled surface (ground laying, colour dusting), the use of local exhaust and other precautions are necessary. One means of applying coloured designs on glazed ware is by means of lithographic transfers, and although the manufacture of the transfers is not necessarily a pottery process, it is so closely allied to it that it is included generally in regulations applying to the pottery industry. After the design has been engraved on stone and the pattern printed in an oily medium on duplex paper, the required colours are dusted on dry; each colour in the design requires a separate passage through a lithographic printing machine followed by dusting with the appropriate colour and subsequent cleaning off of superfluous colour; efficient local exhaust is required at each dusting and cleaning operation. The finished sheets, known as ceramic transfers, go to the "lithographing shop" of the pottery where they are cut up; the thin tissue with the colour
on it is separated from the stiff backing on the duplex paper and applied to the ware, the paper being ultimately washed off leaving the colour design on the ware, just as in the simpler printing process described above.

**Dangers**

The pottery industry is one causing a high rate of morbidity and mortality, both in the processes giving rise to dust, and lead poisoning. Incidentally, too, the variations in temperature to which some of the workers are exposed give rise to rheumatism and diseases of the chest. A further danger to young persons arises from the lifting and carrying of heavy weights, notably in warehouses and packing departments. The degree of sickness, however, is very much modified, according to the manner in which the industry is practised — whether in a factory or as an uncontrolled home industry, as described by Chyzer in Hungary in his brochure *Des Intoxications par le Plomb*, the conditions noted were shocking, in respect of the frequency with which he observed paralysis, epilepsy — even among children — and pernicious effect on childbirth. And in the case of factories, conditions existing ten, twenty and thirty years ago were no doubt very different from what they are to-day. This is shown by figures in the statistics given later. In the same way, therefore, in which a malady may be said to be severe, moderate, or slight, so the evolution of an industry such as the pottery industry in regard to illness may also be referred to as being severe, moderate, or slight. The pottery industry is a large one, and close study of the cases that have occurred has been of the greatest help in elucidating the causation, e.g. of lead poisoning, from inhalation of dust and not from absorption through the skin.

**Dust**

The dust danger is incidental to all processes in the making of the body — in compounding and mixing native clays with Cornish stone, china clay, and calcined flint. The early process of grinding and mixing the raw materials of the body is generally done wet. In the work carried on in the potters’ shops, dust arises from the scraps of clay, which dry upon the floor; this is, however, much more marked after the clay articles have been dried. After moulding, the article is trimmed and finished — the process known as “fettling” — and if the articles are what is known as “white hard” dust is given off in the process. Quantities of dust are given off in the towing of earthenware and certain other fettling processes.

For the first firing, from which the ware emerges in the state known as “biscuit”, many articles are embedded in siliceous material, some of which adheres to the ware and has to be brushed off. For earthenware, sand is commonly used as a bedding material and the subsequent earthenware biscuit brushing gives rise to some dust. In connection with china and other ware for which powdered flint replaces sand as a bedding material, there may be a number of processes in which dust is evolved; these include the placing prior to firing, and subsequently: (1) emptying the ware from saggers, (2) knocking off the flint therefrom, (3) flat knocking, (4) fired flint sifting, (5) emptying baskets of ware for scouring, (6) scouring, (7) fine brushing, (8) bat. In all of these processes dust is evolved.

**Lead**

Apart from the risk of dust arising from uneven floors or benches and from cleaning or brushing these down with insufficient moisture, the following special dangers require mention.

In dipping the ware the glaze is splashed on to the face and overalls of the dipper and his assistants, and the ware cleaners. These splashes soon dry, and the overalls may become so stiff with the glaze that every movement — as in carrying boards — causes it to crumble off as dust, and so become inhaled from the air. Ware cleaning may have to be done so rapidly as to prevent all the dust being carried away by the exhaust.

Dipping boards, unless thoroughly washed after use, create dust when wet. Dipping the ware is placed on them or removed from them when they are handled and placed on, or taken off, the stillage bars, and when they are stacked. Danger arises at the mangle owing to dust, and the glaze placed makes dust when removing the ware from the board and placing it in the sagger. The very dangerous practice — formerly almost universal — of rubbing the bottoms of cups and other articles together, or rubbing them on a piece of leather fixed round the chest, is now replaced by removing the glaze with a moist piece of flannel.

In the decorative processes — ground...
lathing and colour dusting — the danger is from dust containing a high percentage of lead from the enamels used (30-50 per cent.) and in colour blowing from the spray, holding in suspension, as it does, the same enamel colours. A further danger in some of the decorative processes where turpentine or turpentine substitutes are used is the occurrence of dermatitis.

Results of Examination of the Air

Dusty processes. — Aspirating a known volume of air at breathing level through a filter filled with cotton wool, separating the dust from the air, and subsequently (with the usual precautions) weighing the dust, the following are some of the results obtained by G. Elmhurst Duckering:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Present in 10 cubic metres of air (mg.)</th>
<th>Estimated time (in hours) during which inhalation took place</th>
<th>Approximate quantities of lead expressed in milligrams inhaled by worker per day</th>
<th>Percentage of lead in dust</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total dust</td>
<td>Lead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earthenware dipping</td>
<td>38</td>
<td>1.80</td>
<td>74 0.69 (average of 4 expts.)</td>
<td>8.30</td>
<td>Dip. boards not used</td>
</tr>
<tr>
<td>Earthenware dipping</td>
<td>84</td>
<td>6.27</td>
<td>74 2.40 (single expt.)</td>
<td>7.42</td>
<td>Very dirty dipping boards used, work very rapid, and much shaking of ware after dipping</td>
</tr>
<tr>
<td>China dipping</td>
<td>36</td>
<td>2.12</td>
<td>74 0.83 (average of 4 expts.)</td>
<td>5.43</td>
<td>China glaze usually contains about two-thirds as much lead as that of earthenware</td>
</tr>
<tr>
<td>Rockingham ware dipping</td>
<td>44</td>
<td>2.26</td>
<td>74 0.88 (single expt.)</td>
<td>14.37</td>
<td>Dirty dipping boards in use. Glaze contains three times as much lead as ordinary earthenware glaze, but the ware is not shaken after dipping</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cleaning done in or at front of exhaust hood</td>
</tr>
<tr>
<td>Earthenware cleaning</td>
<td>47</td>
<td>2.29</td>
<td>74 0.68 (average of 7 expts.)</td>
<td>5.00</td>
<td>Very defective exhaust; hood so arranged that cleaning had to be done outside; glaze contains about two-thirds as much lead as that for earthenware</td>
</tr>
<tr>
<td>China ware cleaning</td>
<td>123</td>
<td>13.34</td>
<td>6 4.08 single expt.</td>
<td>10.85</td>
<td>Filter placed at breathing level in centre of drying stillage</td>
</tr>
<tr>
<td>Earthenware drying</td>
<td>25</td>
<td>2.10</td>
<td>8 0.30 (average of 3 expts.)</td>
<td>8.58</td>
<td>Boards used were fairly dirty</td>
</tr>
<tr>
<td>Earthenware glazed placing</td>
<td>34</td>
<td>2.68</td>
<td>83 0.33 (average of 3 expts.)</td>
<td>6.58</td>
<td>One man only working</td>
</tr>
<tr>
<td>China glazed placing</td>
<td>30</td>
<td>1.08</td>
<td>9 0.50 (single expt.)</td>
<td>3.64</td>
<td>Tiles cleaned, while still damp, with knife. Much dry waste glaze on wooden floor, and much traffic. Several cases of lead poisoning in this room</td>
</tr>
<tr>
<td>China glazed placing</td>
<td>21</td>
<td>0.32</td>
<td>94 0.16 (single expt.)</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>Majolica-painting of tiles</td>
<td>61</td>
<td>9.11</td>
<td>74 3.48 (single expt.)</td>
<td>15.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Occupations</th>
<th>Dust per 1,000 cubic feet of air: total dust (mg.)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tile pressing</td>
<td>Exhaust not applied to either press or fettling</td>
<td>1.907</td>
</tr>
<tr>
<td>Tile pressing</td>
<td>Exhaust applied to press but not to fettling</td>
<td>0.568</td>
</tr>
<tr>
<td>Tile fettling</td>
<td>Exhaust not applied to either press or fettling</td>
<td>2.892</td>
</tr>
<tr>
<td>Tile fettling</td>
<td>Exhaust applied to press and to fettling</td>
<td>0.250</td>
</tr>
<tr>
<td>Badly ventilated potters' shops</td>
<td></td>
<td>5.843</td>
</tr>
<tr>
<td>Emptying china biscuit from saggers</td>
<td></td>
<td>2.385</td>
</tr>
<tr>
<td>Knocking china flat ware by hand, with no exhaust</td>
<td></td>
<td>16.000</td>
</tr>
<tr>
<td>China scouring — closed machine with exhaust</td>
<td></td>
<td>4.888</td>
</tr>
<tr>
<td>China scouring and fine brushing with exhaust applied</td>
<td></td>
<td>4.600</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Dust per 1,000 cubic feet of air: total dust (mg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthenware dipping</td>
<td>38.00</td>
</tr>
<tr>
<td>Earthenware dipping</td>
<td>84.00</td>
</tr>
<tr>
<td>China dipping</td>
<td>36.00</td>
</tr>
<tr>
<td>Rockingham ware dipping</td>
<td>44.00</td>
</tr>
<tr>
<td>China dipping</td>
<td>47.00</td>
</tr>
<tr>
<td>China ware cleaning</td>
<td>123.00</td>
</tr>
<tr>
<td>Earthenware drying</td>
<td>25.00</td>
</tr>
<tr>
<td>Earthenware glazed placing</td>
<td>34.00</td>
</tr>
<tr>
<td>China glazed placing</td>
<td>30.00</td>
</tr>
<tr>
<td>China glazed placing</td>
<td>21.00</td>
</tr>
<tr>
<td>Majolica-painting of tiles</td>
<td>61.00</td>
</tr>
</tbody>
</table>

American authorities summarise as follows the risks met with in the pottery industry: (a) Mixing of materials for preparation of the fritted glaze; grinding of the fritted glaze; mixing the latter with lead or other
substances; sieving; suspension in water of the product obtained. Risks: shovelling; weighing; transport of the glaze; grinding; sieving of the glaze. The risks are diminished when proper precautions are taken.

(b) Dipping of the piece in liquid glaze; drying; transporting to the ovens. Risks: splashes of glaze on the arms of the worker, on his clothes, and on the floor of the workroom. The splashes, once dried, are transformed into powder, which contaminates the surrounding atmosphere. Shelves should be made of cement and damped. The assistant dippers, who clean the pieces of ware after dipping, and place them on the shelves for transport to the ovens, are exposed to dust from these shelves and from the dried ware.

c) Firing. Workers are sometimes engaged wholly in placing the ware in saggars; sometimes they are also obliged to remove the excess of glazing material (a very dirty operation). Risks: lead dust. This work should be done while the pieces of ware are still wet.

(d) Decoration; preparation of the colours; application of the first coating of colour with a pad or by the spray method. This process should be carried out under a hood furnished with a ventilating apparatus for removal of dust and fumes. Where such apparatus is provided and functions adequately, the danger is very slight. Risks: this work is extremely dangerous unless the decorating processes are effected in the manner just referred to.

e) The manufacture of household articles, etc., in yellow earthenware, containing from 40 to 50 per cent. of a mixture of white lead and minium, as well as articles containing 10 to 50 per cent. of lead, work in the course of which workers are exposed to the risk of lead poisoning (dust).

As regards glazing with a fritted lead glaze, American authorities are of the opinion that when carefully prepared these glazes are practically insoluble in almost all the diluted chemical reagents. In this manner the workers would appear to be safe from the possibility of lead poisoning. The use, therefore, of fritted glazes reduces the danger of lead poisoning, which becomes confined merely to the operations involved in the preparation of the fritted compounds. Fritted lead glaze can be used by itself or in combination with various other materials. The quantity of soluble lead present in the glaze is then diminished and the danger from lead poisoning reduced.

STATISTICS

In Belgium Schoofs (1913) made a study of pottery processes in which cases of lead poisoning occurred, but no statistics are available in regard thereto. The improvements introduced in regard to methods of work, the elimination of lead from certain enamels used, together with attention to personal cleanliness, have certainly contributed to the reduction of the frequency of lead poisoning in the industry.

In France the notification of lead poisoning, rendered compulsory by the Act of 1919, has resulted in the return of 23 cases in 1923, 23 in 1924, 21 in 1925, 45 in 1926, 25 in 1927, 29 in 1928, 33 in 1929, 16 in 1930, 14 in 1931.

An enquiry made by Heim de Balsac, Agasse-Lafont and Feil (1924) into the lead risk amongst workers in pottery and porcelain factories, has revealed the existence of the lead line amongst 50 per cent. of the workers, who had all red corpuscles with punctate-basophilia. No worker, however, had suffered from colic, though certain of them had been in the factory for 37 years. In the departments of the factory other than the enamelling department, the presence of the blue line and punctate basophilia was not so frequent, though far from being negligible.

In Germany several enquiries made over some time have served to draw attention to health conditions in the pottery industry.

An official report for the period 1900-1903 dealt with 13,968 establishments and covered 312,570 workers. 42,664 of whom were women, and 4,931 young girls. 10,362 workers (3.3 per cent.) in 1,672 establishments were using lead glazes. The average figures for the period 1900-1903 are as follows:

<table>
<thead>
<tr>
<th>Nature of manufacture</th>
<th>Number of firms</th>
<th>Number of workers in contact with lead</th>
<th>Per 100 sick workers insured</th>
<th>Per 100 workers in contact with lead:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absolute number</td>
<td>Percentage</td>
<td>From all causes</td>
<td>From respiratory diseases</td>
</tr>
<tr>
<td>Brick and tile works</td>
<td>960</td>
<td>91,306</td>
<td>194</td>
<td>0.9</td>
</tr>
<tr>
<td>Potteries</td>
<td>41</td>
<td>4,866</td>
<td>166</td>
<td>3.4</td>
</tr>
<tr>
<td>Manufacture of earthenware</td>
<td>21</td>
<td>8,630</td>
<td>1,347</td>
<td>15.6</td>
</tr>
<tr>
<td>Manufacture of porcelain, etc.</td>
<td>74</td>
<td>20,626</td>
<td>1,882</td>
<td>9.1</td>
</tr>
</tbody>
</table>

The same occupational categories: Local Sickness Fund, Leipzig
According to the Leipzig Sickness Fund, the pottery workers showed a rate of days of sickness which exceeded by about 10 per cent. the average rate. The morbidity among the workers was higher than for all the members of the Fund together; about 40 per cent. higher for respiratory diseases; 20 per cent. for diseases of the digestive system and about 5 per cent. for diseases of the skin. Forms of rheumatism were equally more frequent, as well as external lesions which were about 20 per cent. below the average (Leymann).

The Federation of Workers in the Porcelain Industry have supplied "morbidity" figures covering the period 1907-1913. Cases of sickness amounted to 29.7 per 100 members, with 700 days of sickness. Amongst cases of sickness were found diseases of the throat (0.54 per cent.), catarrh of the upper respiratory passages (0.86 per cent.), lower (0.025 per cent.), diseases of the lungs (2.58 per cent.), tuberculosis (0.59 per cent.), diseases of the nervous system (1.147 per cent.), of the senses (0.774 per cent.), influenza (4.31 per cent.), rheumatism (4.4 per cent.), lead poisoning (0.112 per cent.), diseases of the digestive system (2.67 per cent.), of the kidneys (0.43 per cent.), wounds (2.51 per cent.), etc.

In the royal china factory at Meissen, employing an average of 550 workers, there were during the period 1904-1915, 27 cases of sickness per 100 workers, with 914.1 days of sickness. Amongst the cases of sickness, affections of the respiratory passages amounted to 3.6, 1.6 of these being tubercular. Koelsch found that in the Bavarian potteries high temperatures and humidity might furnish an explanation of the high incidence of respiratory diseases and disease forms due to cold. He also found out that the suspension of dust in the atmosphere of the workrooms in the potteries contained 20 per cent. and over of the dust in the air.

Amongst the porcelain workers Koelsch frequently met with conjunctival catarrh, catarrh of the pharynx, and respiratory diseases, though complaints as to serious ill health of this kind were rare. 9 in 500 male workers (1.8 per cent.) and still fewer amongst 500 women workers. These troubles consisted in obstructive forms of catarrh of the respiratory passages and asthmatic affections. Medical examination showed the existence of three distinct types; acute chronic irritation of the respiratory passages, subacute forms and tuberculosis. Men were found to be more frequently attacked than women, and the workers most frequently affected were the turners. Tuberculosis affected 3 per cent. of the men and 10 per cent. of the women. It is obvious that the incidence of this lesion is in strict relation to the quality of the dust encountered (Koelsch, loc. cit.). In cases evolving slowly, however, the disease followed a benign form. Whilst the number of cases of respiratory diseases due to dusts was very high, and even after five years of work reached 30 per cent. amongst the men and 30 per cent. among the women of ages averaging from thirty to thirty-five, clinical examination revealed no characteristic results, and the differential diagnosis between pneumoconiosis and tuberculosis is extremely difficult. Thiele has also studied this question and, on the basis of 668 examinations made under fairly difficult conditions and without the aid of X-rays, was only able to find 6 cases of tuberculosis amongst 100 workmen and 5 amongst 100 women workers. Lead poisoning was very rare.

Lehmann likewise does not believe that a high incidence of tubercular infection exists amongst the workers in this industry.

Harms, with the aid of X-rays, found amongst 41 women workers in the porcelain industry 31 cases of pneumoconiosis (75.7 per cent.) and Roessle found 29 cases amongst 45 women workers examined (44.4 per cent.).

The Jena school are of the opinion that porcelain dust may in the long run exert an irritating action, with formation in the pulmonary tissue of a reactive tissue, which may easily be confused with tuberculosis. It also lays stress on the concomitant action of other factors, such as social conditions, general conditions of hygiene, as well as personal circumstances.

Holtzmann and Harms have studied the question of inhalation of dusts amongst workers in the porcelain industry (1933). Their enquiry led them to the conclusion that subjective symptoms are in general very slight, not only at the beginning of the career (ten years), but even later, and that there is no evident relation between the duration of inhalation of dust and the outbreak of bronchial symptoms. In the majority of the cases physical symptoms are almost negative. Under the X-rays these are existent only in advanced cases, which, however, cannot be said to present a characteristic peculiarity. The authors in question formed the conclusions of De la Camp, and admit that symptoms of pneumoconiosis without complications are most usually very slight and even negative. Amongst the complications found were chronic bronchitis and acute or chronic broncho-pneumonia. Tuberculosis is very rare in the Baden factories, and therefore of slight importance amongst these workers. Where it occurred, it followed a benign course.

Meyer (1924) recalls that in the small potteries of Hesse there is used as a glaze no oxide of lead (litharge) but lead sulphite (galena), probably because the latter has a lower point of fusion. Since 1917 and up to 1924 these workshops only used minium for glazing. The danger exists in the fact that with this composition a greater quantity of lead in the form of oxide remains in the receptacle than is the case with other glazing materials.

In 1925 Gerbis examined 128 workers in a pottery factory who had come in contact with glazing products; 23 were not twenty years of age; 42 were under thirty; 54 under sixty, and over that age. Gerbis found that the best conditions from a
Health point of view were met with in the workshops where fritted glaze was handled, and in those workshops where crude glaze was manipulated when the work was done in a wet state. He also was impressed by the importance of personal cleanliness as a means of prevention.

Of 85 workers 19 had already suffered from symptoms of lead poisoning; colic, 8 cases; lead line, 12; punctate basophilia, 5; digestive derangements, 4; nervous derangements, 1. Out of 43 women workers 4 were found to have suffered from lead colic; 18 had lead line; 17 punctate basophilia; while 6 suffered from digestive derangements and 7 from nervous troubles.

The total number of persons, in Great Britain, employed in the china and earthenware industry, is estimated at about 65,000, of whom about 25,000 are employed in processes involving exposure in some degree to dust of clay and flint, and about 7,000 in processes involving risk of lead poisoning.

Dr. Middleton has furnished the following account of the results of an investigation undertaken by the Home Office in 1925 into the incidence of silicosis in the pottery industry in North Staffordshire:

"The work was carried out by two medical men with special knowledge of silicosis, with the assistance of a medical radiologist. A number of workers were selected from some thirty occupations in which the workers are exposed to inhalation of dust. In all, 532 persons were examined clinically, and 230 were X-rayed.

Evidence of silicosis was found in those employed in china placing, where dry flint is used, and in the subsequent incidental processes; in the use of sand as a placing material; in the milling of flint and in the sliphouse; in processes of manipulation of the body in the clay state; and, in addition, in saggar making and in ware polishing; in which exposure to flint dust is only incidental. The following table shows the incidence of fibrosis of the lungs as found by clinical examinations in certain of the groups of workers; the numbers examined radiologically, and those in whom evidence of silicosis was found, in the same groups:

<table>
<thead>
<tr>
<th>Workers exposed to unmixed flint dust</th>
<th>Clinical examinations</th>
<th>Diagnosed fibrosis</th>
<th>Radiological examinations</th>
<th>Diagnosed silicosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M.</td>
<td>F.</td>
<td>Total</td>
<td>M.</td>
</tr>
<tr>
<td>China, including placers, oddmen, and warehouse women</td>
<td>37</td>
<td>40</td>
<td>77</td>
<td>26</td>
</tr>
<tr>
<td>Flint milling</td>
<td>19</td>
<td>—</td>
<td>19</td>
<td>—</td>
</tr>
</tbody>
</table>

Workers exposed to dust from composite body:

<table>
<thead>
<tr>
<th>Workers exposed to dust from composite body</th>
<th>Clinical examinations</th>
<th>Diagnosed fibrosis</th>
<th>Radiological examinations</th>
<th>Diagnosed silicosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>General earthenware: from sliphouse to lookers to ware</td>
<td>88</td>
<td>89</td>
<td>177</td>
<td>49</td>
</tr>
<tr>
<td>China Ditto</td>
<td>53</td>
<td>17</td>
<td>70</td>
<td>28</td>
</tr>
<tr>
<td>Ttiles, including sliphouse and pressers</td>
<td>8</td>
<td>19</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td>Sanitary earthenware body, including casters and pressers</td>
<td>20</td>
<td>—</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>Electrical earthenware: sliphouse to fellers</td>
<td>21</td>
<td>30</td>
<td>51</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>240</td>
<td>195</td>
<td>435</td>
<td>136</td>
</tr>
</tbody>
</table>

* An interesting result of the investigation is the evidence of the incidence of silicosis amongst workers whose occupations expose them to the inhalation of dust consisting of the mixed ingredients of the composite body of the ware in which flint occurs. The evidence tends to indicate that free silica, in the form of flint or quartz, is the most important factor in the causation of serious respiratory disease in the industries. It is obvious, when the occupations are considered in which silicosis was found, that the degrees of risk vary within very wide limits; thus, the group of occupations in which dry flint is used in china placing, scouring, etc., show a high incidence of silicosis amongst those examined. In the case of the female workers the proportion of persons employed for more than twenty years tends to fall, consequently the incidence of silicosis amongst them, while continuing at work in the industry, is lower than amongst the male workers. It is significant that in the occupations where the incidence of silicosis is high,
it becomes evident at an early stage in the occupational history of the workers. This feature may be regarded as a true measure of the severity with which silicosis is likely to occur under given conditions.

An investigation was made into the atmospheric dust in certain branches of the pottery industry, to provide a connecting link between the state of health found by examinations of the workers and the hygienic conditions under which their work is carried on.

From the point of view of the dust hazards the occupations in the industry fall into four groups: (1) those in which the raw materials are handled; (2) the manipulation of the composite body of the ware; (3) the use of flint or sand for embedding the ware in firing, and its subsequent removal from the ware; (4) occupations involving exposure to other dusts, as in mould- and squeaker-making.

The dust samples were taken with Owens' dust-counter at the breathing level of the worker.

"In the milling of flints, for use in pottery manufacture, the most dangerous process is that of crushing the flints in a machine crush roller. A sample taken to the ward of such a machine gave 4,314 particles in 1 c.c.; 8 were over 1,000; 11 were over 500, and 4 were under 500 particles. Of these, 6 gave counts of over 2,000 particles in 1 c.c.; 8 were over 1,000; 11 were over 500, and 4 were under 500 particles. The proportion of mineral (flint) particles in the counts varied from 15 to 50 per cent.

In the process of placing china ware in flint for firing 29 samples were taken. Of these, 6 gave counts of over 2,000 particles in 1 c.c.; 8 were over 1,000; 11 were over 500, and 4 were under 500 particles. The proportion of mineral (flint) particles in the counts varied from 15 to 50 per cent.

"In china potters' shops 8 samples gave counts from over 3,000 to over 7,000 particles in 1 c.c., the proportion of mineral (composite body) varying from 15 to 80 per cent. This series of dust counts is sufficient to indicate that a source of danger exists in workrooms in which the china body is in the damp, or even wet, state. The processes of taking the fired china ware from the saggers and removing adherent flint dust from it produce much dust. The counts of 13 samples taken at these processes range from over 5,000 to over 11,000 particles in 1 c.c., the proportion of mineral (flint) being from 20 to 80 per cent.

"In the manufacture of earthenware, dust is produced in fashioning the ware from the body in the potters' shops, and in toning. In 18 samples in this series the counts range from over 300 to over 2,000 particles in 1 c.c. Some of these represent what appear to be definitely dangerous atmospheres. The processes in the manufacture of tiles, sanitary earthenware and electrical fittings are similar and gave similar results to those found in the manufacture of earthenware."

In Great Britain mortality statistics, have been carefully prepared by the Registrar-General, who, every ten years, has surveyed the mortality of men in a large number of occupations, and he has adopted a comparative mortality figure in regard to twenty-two different causes of death in all the industries.

The following is the comparative mortality figure of males aged twenty-five to sixty-five years in 1910-1912 from: (1) all causes; (2) phthisis; (3) gout; (4) lead poisoning; (5) diseases of the nervous system; (6) bronchitis; (7) pneumonia; (8) other diseases of the respiratory system; and (9) Bright's disease, among (a) all occupied and retired males, (b) coal miners, (c) printers, (d) potters, (e) dock labourers, and (f) cutlers:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>All causes</th>
<th>Phthisis</th>
<th>Gout</th>
<th>Lead poisoning</th>
<th>Diseases of nervous system</th>
<th>Bronchitis</th>
<th>Pneumonia</th>
<th>Other respiratory diseases</th>
<th>Bright's disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>All occupied and retired males</td>
<td>790</td>
<td>141</td>
<td>1</td>
<td>1</td>
<td>85</td>
<td>37</td>
<td>67</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>Coal miners</td>
<td>727</td>
<td>75</td>
<td></td>
<td>2</td>
<td>72</td>
<td>50</td>
<td>65</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Printers</td>
<td>773</td>
<td>198</td>
<td>1</td>
<td>2</td>
<td>102</td>
<td>31</td>
<td>50</td>
<td>13</td>
<td>32</td>
</tr>
<tr>
<td>Potters</td>
<td>1,156</td>
<td>241</td>
<td>1</td>
<td>12</td>
<td>51</td>
<td>31</td>
<td>69</td>
<td>54</td>
<td>43</td>
</tr>
<tr>
<td>Dock labourers</td>
<td>1,127</td>
<td>231</td>
<td></td>
<td>2</td>
<td>89</td>
<td>81</td>
<td>146</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>Cutlers</td>
<td>1,285</td>
<td>466</td>
<td></td>
<td>2</td>
<td>72</td>
<td>82</td>
<td>85</td>
<td>44</td>
<td>56</td>
</tr>
</tbody>
</table>

From these it will be seen how much in excess is the mortality from phthisis, respiratory diseases, and lead poisoning. Dr. Tatham, the Superintendent of Statistics, wrote as follows of the potter in the decennium 1900-1902:

"Pottery, earthenware, etc., manufacture. — Between the ages of twenty and thirty-five years the mortality of potters falls below that of occupied and retired males generally; at every other age, however, it shows an excess which amounts to no less than 74 per cent., between ages 30-50."

1 The comparative mortality figure represents the number of deaths that would have occurred if the occupational death rates from the several causes and at the several age-groups had been operating upon a sample of the general male population enumerated at the census of 1911, which at that time (1900-1909) produced 1,000 deaths. This standard population is 71,065.
POTTERY INDUSTRY

forty-five and fifty-five years, and to 66 per cent. between ages fifty-five and sixty-five years. In the main working time of life the comparative mortality figure is 49 per cent. above the standard. The principal excess falls under the head of respiratory diseases, for which the mortality figure is nearly thrice the standard. There is also a considerable excess in the mortality from phthisis, from nervous and circulatory diseases, and from suicide. These workers are also specially liable to lead poisoning.

Lead. — In Great Britain, fortunately, excellent statistics as to morbidity from lead poisoning in the potteries are available for more than a quarter of a century, owing to the obligatory notification of lead poisoning (and certain other forms of poisoning) required, first, under the Factory and Workshop Act of 1895. These statistics have been kept on a uniform plan for many years past, and from time to time (when incidence of poisoning had to be closely watched) a census of persons employed in the different processes was taken, so that an attack rate per thousand employed in the different processes could be obtained. The pottery industry in Great Britain comprises seven main classes: china, earthenware, tiles, majolica, Jet and Rockingham, china furniture and electrical fittings, and sanitary ware. These can all be separately dealt with. First, however, figures may be given from 1901 onwards of the actual number of cases reported:

Years | All causes | Tuberculosis | Bronchitis | Pneumonia | Chronic nephritis
--- | --- | --- | --- | --- | ---
1901-1911 (average) | 777 | | | | 
1912-1914 | 571 | 49 | 474 | 146 | 221
1915 | 472 | | | | 
1916 | 471 | | | | 
1917 | 146 | | | | 
1918 | 221 | | | | 
1919 | 141 | | | | 
1920 | 230 | | | | 
1921 | 97 | | | | 
1922 | 87 | | | | 
The raised figures relate to deaths.

The table at the top of page 707 gives the number of reported cases and the proportion of cases to persons employed, in the several classes of earthenware and china works, and in the various processes, from 1901 to 1911.

The figures in this table show that the greatest risk incurred is in the earliest processes to dippers, and to their assistants, the ware cleaners, and also how, by successful application of preventive measures in the shape of exhaust ventilation, periodical medical examination, and, finally, substitution of leadless or low solubility glazes for the raw lead glazes formerly used, the danger from lead poisoning has been greatly reduced. In 1925 it was stated that practically no cases of acute plum-bism were occurring, but that such cases as were reported were due to the sequelae of lead poisoning — e.g. chronic Bright’s disease, cerebral haemorrhage — contracted under the unsatisfactory conditions that prevailed many years ago.

It will be seen that the pottery figures show a marked diminution in morbidity without a corresponding diminution in mortality. This is partly due to the fact that cases such as those just mentioned sometimes do not become included in the statistics until after death, when as a result of official enquiry into the cause of death the fact that it was ultimately due to or hastened by lead poisoning is brought to light.

In Hungary, B. Chyzer studied (in 1908) the incidence of lead poisoning amongst pottery workers, and he has drawn attention to the incidence of cases of tetanus, several of which were met with amongst the children of pottery workers. The incidence of tuberculosis was connected by this expert with the action of quartz dust. He found lead poisoning to have occurred very frequently, and with very serious consequences.

In Italy, Guidelli effected an enquiry into the pottery industry at Laveno, where he met with 8 cases of lead poisoning per 100 workers. The enquiry dealt with 500 workers. In 1908 R. Marcello studied the same industry in Sardinia, and in 1907 Pieraccini published the results of a very thorough enquiry carried out in Tuscany. He examined conditions in all branches of
the pottery industry, and studied not only the hygienic and sanitary conditions of the workers, but also several improvements made in industrial technique in a large factory in the district, and he was thus able to bring to light the favourable result is that tuberculosis in all forms has the protection of the workers' health. The industry.

In dipping house:

<table>
<thead>
<tr>
<th>Processes</th>
<th>Cases reported in 1911 as occurring in works for the manufacture of</th>
<th>Cases reported as occurring in (average)</th>
<th>Attack rate per 1,000 employed (average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----------------</td>
<td>---------------------------------------------------------------</td>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Dippers</td>
<td>M. 788 F. 150</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Dippers, assistants</td>
<td>M. 403 F. 100</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ware cleaners</td>
<td>M. 112 F. 461</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>M. 1,464 F. 1,008</td>
<td>6</td>
<td>11</td>
</tr>
</tbody>
</table>

Occupations

<table>
<thead>
<tr>
<th>Occupations</th>
<th>Number of persons employed</th>
<th>Fatal cases</th>
<th>Percentage per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decorators</td>
<td>3,010</td>
<td>57</td>
<td>1.9</td>
</tr>
<tr>
<td>Turners and polishers</td>
<td>2,705</td>
<td>108</td>
<td>4.0</td>
</tr>
<tr>
<td>Various</td>
<td>6,065</td>
<td>55</td>
<td>2.6</td>
</tr>
<tr>
<td>All other occupations</td>
<td>15,410</td>
<td>300</td>
<td>2.4</td>
</tr>
</tbody>
</table>
According to Levitzky, 50.7 per cent. of the turners suffered from some form of respiratory diseases. As the result of experience in Russia, the use of a wet sponge in the polishing of ware is said to be productive of good results.

An enquiry made in 1925 amongst the pottery workers in four villages of the district of Jegorjewitz (Government of Moscow), who were engaged on home work, and 24 of whom were submitted to medical examination (17 had worked over periods varying from eleven to fifteen years) showed that 4 only were free from symptoms of lead poisoning.

In Sweden an enquiry carried out in 1928 by the Department for Social Affairs covered 6 factories; 71 persons were examined, 39 men and 30 women over eighteen years of age, and 2 women under eighteen. Amongst these, 29 were engaged in finishing and dusting off, 6 in warehouse work and in grinding, and 6 in fritting. In 4 factories only lead glazes were used, and in 1 only leadless glaze.

The enquiry revealed a single case of lead poisoning, affecting a dipper who had been working for fifteen years. Another worker had been treated thirty-eight years previously for a form of lead poisoning, but at the moment of the enquiry he showed no symptom of poisoning. Further, amongst 42 per cent. of the individuals examined, slight symptoms only, due to the chronic absorption of lead, were met with: pain in the joints (7); colic (5); constipation (2); headache (5); blue line (6); trembling of the hands (1); radial-paralysis (1); anaemia (5); blood-pressure above 150 mm. (8); red corpuscles with punctate-basophilia (up to 300 and over per million) (23); albumen in the urine (2).

The state of health of the workers was recognised to be better in those factories which used only fritted lead. The workers most exposed to risk seemed to be those engaged on fritting and dippers.

In the United States enquiries into the pottery industry have been carried out by Hamilton (1910-1911), Hayhurst (1914), and the majority of them contain high proportions of soluble lead. Out of 107 samples 73 per cent. contain over 10 per cent. of soluble lead, and 11 more 20 to 50 per cent. Similarly, the cleaning of enamelled ware is often executed in America after a day spent in dipping, and in this way the operation is an extremely dangerous one.

In 1911 the conditions in potteries were very bad, especially in the glazing and decorating departments: lack of cleanliness, dry-cleaning of the shelves, etc. Hamilton found that amongst the 1,100 male workers in the potteries of New Jersey and Ohio in 1911, there were 87 cases of lead poisoning, and amongst 400 women workers, 57 cases.

The enquiry made by Hayhurst in 1914 affected 47 factories of the State of Ohio, giving employment to 8,146 workers, 2,555 of whom were exposed to the risk of lead poisoning, and 109 of whom showed symptoms of poisoning.

The enquiry made by the Public Health Service in 1919-1920 covered 92 factories in New Jersey, Ohio, Western Virginia, Kentucky, Tennessee, Indiana, Illinois, Wisconsin and Pennsylvania. Dr. Hamilton, from reports made by medical men furnished by hospitals as well as from her own experience, was able to collect a total of 217 cases of lead poisoning, distributed amongst 1,912 workers. The majority of the cases affected workers engaged in enamelling, who numbered in all 900.

The type of poisoning is often very serious; thus, in four potteries in the neighbourhood of Pittsburg, there were found amongst 365 workers 165 cases of lead poisoning, with 11 deaths, 25 cases of paralysis and 8 cases of encephalopathy.

It should be remarked that in the American pottery industry the lead compound is mostly added after the fritting of the glazing material, so that its solubility is not in the least diminished. All the American glazes are lead glazes, and the majority of them contain high proportions of soluble lead. Out of 107 samples 73 per cent. contain over 10 per cent. of soluble lead, and 11 more 20 to 50 per cent. Similarly, the cleaning of enamelled ware is often executed in America after a day spent in dipping, and in this way the operation is an extremely dangerous one.

<table>
<thead>
<tr>
<th>Age-groups</th>
<th>Hayhurst</th>
<th>Public Health Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of workers</td>
<td>Lead poisoning</td>
<td>Percentage</td>
</tr>
<tr>
<td>Below 30</td>
<td>73</td>
<td>5</td>
</tr>
<tr>
<td>From 30 to 39</td>
<td>2,083</td>
<td>66.1</td>
</tr>
<tr>
<td>.. 40 .. 44</td>
<td>324</td>
<td>19</td>
</tr>
<tr>
<td>.. 45 .. 49</td>
<td>78</td>
<td>8</td>
</tr>
<tr>
<td>Above 50</td>
<td>55</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>2,567</td>
<td>109</td>
</tr>
</tbody>
</table>
The time during which the workers had been exposed to risk was distributed as follows:

<table>
<thead>
<tr>
<th>Duration</th>
<th>Hamilton</th>
<th>Hayhurst</th>
<th>Public Health Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 11 months</td>
<td>38</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>1 to 4 years</td>
<td>36</td>
<td>35</td>
<td>17</td>
</tr>
<tr>
<td>5 to 9 years</td>
<td>63</td>
<td>53</td>
<td>10</td>
</tr>
<tr>
<td>10 years and up</td>
<td>49</td>
<td>43</td>
<td>93</td>
</tr>
<tr>
<td>Total</td>
<td>186</td>
<td>109</td>
<td>132</td>
</tr>
</tbody>
</table>

The special categories to which the lead workers belonged were as follows:

<table>
<thead>
<tr>
<th>Occupations</th>
<th>Hamilton</th>
<th>Hayhurst</th>
<th>Public Health Service</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of workers</td>
<td>Lead poisoning</td>
<td>Percentage</td>
</tr>
<tr>
<td>Mixers (glaze)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Dippers</td>
<td>355</td>
<td>92</td>
<td>25.2</td>
</tr>
<tr>
<td>Dippers' helpers</td>
<td>221</td>
<td>27</td>
<td>12.2</td>
</tr>
<tr>
<td>Warecleaners</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Glaze kiln placers</td>
<td>484</td>
<td>19</td>
<td>4.1</td>
</tr>
<tr>
<td>Sagger cleaners</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Decorators</td>
<td>30</td>
<td>3</td>
<td>15.0</td>
</tr>
<tr>
<td>Others</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>1,970</td>
<td>141</td>
<td>13.2</td>
</tr>
</tbody>
</table>

The causes of deaths amongst pottery workers are shown in the reports of the National Brotherhood of Pottery Workers for the period 1911 to 1919 as follows:

<table>
<thead>
<tr>
<th>Causes of death</th>
<th>1911-1915</th>
<th>1916-1920</th>
<th>Total</th>
<th>Annual average</th>
<th>Percentage of the total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuberculosis</td>
<td>191</td>
<td>112</td>
<td>181</td>
<td>18.1</td>
<td>25.6</td>
</tr>
<tr>
<td>Other respiratory diseases</td>
<td>80</td>
<td>60</td>
<td>110</td>
<td>11.0</td>
<td>14.9</td>
</tr>
<tr>
<td>Diseases of the heart and circulatory system</td>
<td>19</td>
<td>30</td>
<td>39</td>
<td>3.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Nervous diseases</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Paresia and paralysis</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Chronic nephritis</td>
<td>3</td>
<td>12</td>
<td>15</td>
<td>2.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Diseases of the liver and kidneys</td>
<td>19</td>
<td>30</td>
<td>49</td>
<td>4.9</td>
<td>6.9</td>
</tr>
<tr>
<td>Diseases of the digestive system</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Accidents</td>
<td>20</td>
<td>62</td>
<td>82</td>
<td>8.2</td>
<td>11.4</td>
</tr>
<tr>
<td>Infections, etc.</td>
<td>26</td>
<td>48</td>
<td>74</td>
<td>7.7</td>
<td>10.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>215</strong></td>
<td><strong>103</strong></td>
<td><strong>318</strong></td>
<td><strong>26.1</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Cases of lead poisoning (positive, probable and doubtful) amounted to 333 amongst 1,436 workers examined; 8.8 per cent. positive and 14.2 per cent. probable. The positive cases were returned as follows: 13.1 per cent. of workers aged forty years and over; 6 per cent. of those aged twenty-five to thirty-nine years. Amongst the women, cases of lead poisoning affected 80 out of 373 examined, and positive cases were met with chiefly amongst those aged from twenty-five to forty and upwards.

According to the statistics of Hoffmann, 32.2 per cent. of the workers in the pottery industry die of tuberculosis. In a summary of the results of the Ohio enquiry, R. F. Albaugh draws attention to the fact that 5.1 per cent. only, out of 2,882 workers exposed to the risk were over forty-five years of age, which points to the fact that for some reason or other the workers leave the industry before middle age. Of the workers aged over forty-five about 15 per cent. were victims of lead poisoning.

**PATHOLOGY**

Arlidge, who was certifying factory surgeon for Stoke and physician to the North Stafford Infirmary, had great experience of the effects on the workers of the dust and lead in pottery manufacture. In his book, *Hygiene, Diseases and Mortality of Occupations* (1892), he states:

The siliceous constitution of potters' clay is accountable for the mischief it causes
to the lungs; and, as a general rule, the injury caused is greater in proportion to the amount of dust given off in the particular process carried on; with this qualification, that the effects produced are somewhat varied by the proportion in which silex is present. The fictile compound forming the body of china articles is more prejudicial than an earthenware body; and is rendered still more so by the employment of fine flint and sand for placing, and by the necessity subsequently of cleansing the ware from the adherent dust. One branch of the trade suffers more than another according to the quality and quantity of the dust evolved.

Arlidge noticed greater frequency of lung lesions among turners and pressers than among throwers. Injury to health, however, was greatest in the case of china scoters, who, at the time he has been brushed and beat off the dust from the china ware — a proceeding accompanied by the production of clouds of flint dust. This process, however, has been metamorphosed in recent years by carrying out the process in revolving drums, as previously described.

Arlidge says:

When uncomplicated by tubercle, the potters' disease advances imperceptibly, and without constitutional disturbances. One of its first symptoms is a clearing cough on first rising, but soon to become met with on any change of temperature, and accompanied by shortness of breath. Haemoptysis does not usher in the malady, and more frequently than not never makes its appearance. The appetite and the general bodily functions remain long intact; there is no febrile action, no accelerated pulse, no hectic and no rapid emaciation. Anaemia is no necessary adjunct. The sputa remain for long white and frothy, with specks or streaks of black matter, which is inhaled dust. Later on this mucus expectoration gets purulent, heavy, and forms pellets, but is not green. The cough is more paroxysmal and violent than that of phthisis, and the urgency of the dyspnoea greater, and out of proportion to the ascertained extent of consolidated lung. The signs of consolidation are not so specially limited to the infra-clavicular spaces as in tubercular lesion, and hence the sinking below the clavicles is not marked. Areas of dullness on percussion are often found distributed at different parts, particularly in the scapular region, and near the base of the lungs. There is not an equal shrinking and contraction of the thoracic cavity at large. Between these an emphysematous condition is discoverable; a phenomenon more common along the anterior margin of the lungs. There is not an equal shrivelling and contraction of the thoracic cavity at large.

As might be foreseen from the increased strain on the pulmonary circulation, the heart gets frequently involved, the right side becomes dilated, and the valves inefficient; hence anasarca in prolonged cases is no infrequent occurrence before the scene closes. I would add that the general aspect and physiognomy differ from that of tubercular phthisis. The features are rather those of anemic anaemia; subject to a frequent occurrence of the lustrous eye, the often pink and transparent skin of phthisis, the clubbed finger-ends, and the incurved nails are wanting.

But in looking for these distinctive signs, we must never forget how frequently tubercular deposit modifies the picture of fibrosis I have endeavoured to present.

In 1922, H. Zuber, of Geneva, described three fatal cases (with autopsy) of pulmonary lesions without tuberculosis, amongst workers engaged in china manufacture. The lesions were symmetrical, and were located specially in the upper lobes of the lungs. In spite of the fact that the lesions were very serious, there was no tendency to the formation of cavities. Vascular lesions sometimes showed in the form of obliterating arteritis.

Lead poisoning in pottery manufacture does not differ from lead poisoning generally.

In the early period, when little but raw lead glazes were used, with locally applied exhaust ventilation indifferently carried out in several of the processes, inhalation of dust of lead compounds was general, and where inhalation of dust is pronounced there is much greater risk of the more severe symptoms of lead poisoning — encephalopathy (convulsions and blindness) showing themselves. The proportion of cases of this severest form of lead poisoning were noticeably more frequent in the early period.

The Austrian enquiry of 1913 revealed the fact that in glazing factories almost half the workers (45 per cent.) in average-sized earthenware factories and in those of lesser importance, more than one-third (36 per cent.), in workrooms for the decoration of china about one-seventh (14 per cent.), and finally, over one-seventeenth (6 per cent.) in the large pottery factories, might be considered as exposed to the lead risk.

Lead poisoning symptoms amongst workers exposed to the risk of poisoning were found to be present to the following extent:

<table>
<thead>
<tr>
<th>Per cent.</th>
<th>Glazing departments</th>
<th>Earthenware factories (small and average size)</th>
<th>Large factories</th>
<th>Workrooms for decorating china</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td></td>
<td></td>
<td>50</td>
<td>30</td>
</tr>
</tbody>
</table>

Deformations of the lower limbs met with amongst pottery workers working on a lathe have been described in detail.
by Pieraccini. A sufficient explanation thereof is provided by studying the manner in which the worker effects his work. He is seated on a board in front of the setting bench, and rests his left foot on a low plank placed parallel to the seat, so that he may exert the maximum pressure on it. The other foot exerts strong pressure on a wooden disc turning on a central pivot. A vertical axis runs from the centre of this disc, and carries at the top a small disc on which the clay is worked. The circular movement of the lower disc is produced by the left foot, and more rarely by both feet which push it forward in the direction in which the feet move. This kind of dance is executed with bare feet, to economise shoe leather. It is not surprising that in the long run the foot, and especially the left foot, develop a deformity consisting of flat foot and especially of a deviation towards the central axis or towards the outer edge of the foot from the first and partly from the second, third and fourth toes. There is fairly often met with, also a tuberous form of osteoperiostitis, situated on the first metatarsal-phalangeal joint. The left foot is more affected than the right, since it is placed nearer the centre of the disc, where the movement is naturally much more rapid than at the periphery.

Barretoni described in 1923 stigmata (callosities) noted amongst pottery workers. These were processes of epithelial formation on the hands of the workers engaged in finishing plates, saucers, and in general the workers using lathes. Rubbing of the hand against the ware turning at high speed, which is never perfectly smooth, caused on the left hand (thumb, first finger, small finger, thenar and hypothenar regions) and on the right hand (first and middle finger) a lesion which is not serious in itself, but which may provide a path of entry for pathogenic germs.

Russian contributions in the last few years have become very numerous; Atabekian, of Moscow, in studying (1926) the influence of heat on workers engaged in removing ware from the ovens, has remarked an increase of the body temperature, a higher pulse rate, etc. The workers complained of varying symptoms: palpitation, vertigo, etc. The same question was studied by Efremova in 1927.

Kawaleroff and Kagan in 1926 carried out an enquiry into the extent of lead poisoning amongst pottery workers, and studied lesions of the skin and nails amongst workers manipulating glazing products and workers in the decorating departments. The skin of the hands and the forearms was found to be dry, ridged, and sometimes swollen and pale pink in colour, almost as if it had been powdered. The lesions healed with difficulty, for eczema was frequently present.

The nails were thin, furrowed, brittle and painful, cut and eroded at the edges. Amongst women workers engaged in decorating, the use of colouring mediums and of spirit of resins incaused dermatitis, rhagades, and even painful ulcers. They complained of headache, cough and vertigo.

Rostowzwo in 1926 also drew attention to this incidence of skin diseases amongst Russian pottery workers. The lesions were situated at the base of the finger, more rarely on the palm of the hand; they affected especially workers engaged in shaping the clay and sorters. Amongst dippers the lesions (eruptions, drying of the skin, increased sensitiveness) are favoured in development by the irritating action of the liquid into which the ware is dipped.

In 1925 Kalf Kalif, of Kharkov, studied cardiovascular troubles and anaemia amongst workers in the pottery industry; Gertschik in 1927 studied the effects of working by wet methods during polishing, which he found, however, did not give good results except when subdivision of work was adopted in the factory. In fact if the same worker is called upon to perform all the operations of shaping and polishing, he is obliged to handle dry products giving off large quantities of dust. It is therefore essential that the work should be done whilst the materials handled are still slightly damp.

The pathology attaching to this class of workers comprises other lesions, such as: varicose veins in the lower limbs; wounds; rhagades; ulcers either on the hands or on the feet (where workers did not wear shoes); painful arthralgia; neuralgia and neuritis (in one cases located on the cubital edge of the arm; Ceni, 1905); diseases arising from cold; derangements of the digestion; cardiovascular lesions; and in particular arteriosclerosis amongst workers at the ovens (dry heat, high temperature); the risk of lead poisoning during application of the glaze (removal of excess by the cubital edge of the left hand: in certain glazes the lead contained amounts to 75 per cent.); during firing (lead fumes in the workshops where the kilns are not well constructed or are cracked); danger of inhaling silicious dust at all stages of manufacture, but chiefly during the
cleaning of biscuit after withdrawal from the oven by means of brushing in an enclosed space.

HYGIENE

Meticulous attention to detail, not only in the provision, but also in the maintenance, of the locally applied exhaust ventilation alone can allay the danger in the processes in which dust is incidental, whether in body making or in the application of glaze. In manipulating the raw materials of the body in the slip house, wet grinding is the common practice, so that no dust arises. Potters' shops require to be cleaned daily by a moist method, and provided with means for effective ventilation. Locally applied exhaust is required specially in the processes of dry fettling, towing of earthenware, biscuit placing in flint, in emptying the ware from the saggers and the scouring of biscuit ware, etc., unless these processes, e.g., china scouring, can be carried out in closed-in apparatus, preventing the escape of dust into the workroom; but, even then, the "rumbler" requires to be under a negative pressure. Similarly, in the lead processes, so long as they are wet, or removal of the glaze with a damp sponge or flannel is carried out in closed-in space. In the dipping house, impervious floors should be provided, to be washed down so as to prevent the risks from sweeping. The walls adjacent to the dipping tubs should be tiled or painted with washable paint, and cleaned daily.

To reduce risk or remove the danger of lead poisoning in the pottery industry, use of low solubility glazes or of leadless glazes are advocated. On this point the English Committee appointed in 1910, reported:

The effect of melting the lead with siliceous matter practically amounts to imprisoning it in such a manner as to render it less liable to the action of the acids which it meets in passing through the human body, and in consequence largely reduces the likelihood of its absorption into the blood. If the frit is properly compounded, all but a small fraction of the lead is rendered insoluble, and glazes so made are spoken of as low solubility glazes. The finished glaze generally contains from 12 to 22 per cent., or more, of lead oxide, but after the process of fritting with sufficient siliceous material only from 2 to 5 per cent. remains soluble. Raw lead comprises red lead, white lead, and litharge. If introduced in this form as a constituent of glaze it is soluble in dilute acids. If, however, the raw lead is fluxed by heating with a part or the whole of the silica, it is converted into "frited lead". The solubility of the frit depends upon the relative proportions of material taken. Thorpe, as a result of numerous analyses of lead silicates (after determining their solubility as regards lead) both simple and complex, in the use in the potteries and on the Continent, found that the quantity of lead dissolved had no necessary relation to the quantity of lead in the silicate. Primarily and in the main the insolubility of the lead depends not upon any one oxide or group of oxides, but upon the maintenance of a certain proportion between the whole of the basic oxides on the one hand and the whole of the acidic oxides on the other.

If the value of ratio —— higher than 

*acids* bases

or approximately equal to, 2, the amount of the lead extracted is small, but if it falls much below 2, the quantity of lead dissolved begins rapidly to rise.

On the subject of the use of leadless glazes, the Committee conclude that in all classes of pottery ware a great many articles can be manufactured in a very high state of perfection, with reduction in the cost of production of certain classes of common ware, such as jampots and Persian painted ware; but that in certain other classes, owing to the excessive number of "seconds", their use would entail cost or sacrifice of quality, so much so as to involve loss of important markets; and finally, that certain kinds of ware, in consequence of difficulties relative to accuracy in reproducing old patterns, colour, or methods of decoration, cannot at present be made at all without use of lead.

LEGISLATION

Women are excluded from grinding in the pottery industry in Argentina. Young persons under eighteen from pottery workrooms and pipe factories in France where there is free liberation of dust; in Switzerland from manipulation of any non-frited lead glazes. Boys under sixteen years of age and women under twenty-one are excluded from grinding and dipping in Spain; boys under fifteen and women under twenty-one from workrooms in the pottery industry where dust is freely liberated, unless diffusion is effectively prevented, in Italy; from workrooms where there is abundant liberation of clay dust in Japan; young persons under fourteen are excluded from places where dust from grinding and bolting is freely liberated in Belgium; women and children under fifteen are excluded in Estonia (except from shaping of earthenware and porcelain).

Adult women are excluded in the States of New Jersey and Pennsylvania from operations during which all substances or compounds or colours containing more than 2 per cent. of lead are handled, and
in Great Britain from the manufacture and decoration of pottery, mending of bisque with lead glazes, and sealing with lead compounds containing more than 0.5 per cent. of lead (soluble compound), from weighing, shovelling and mixing of non-fritted lead, etc. In France they are excluded from dry-dusting, colour-dusting in chromo-lithography for pottery, where exposure to dust is involved; in Japan from every process where there is production of dust; in Austria to 20 per cent.; in Switzerland women are excluded from manipulation of unfritted lead glazes, etc. (See also in the article "Lead" the Draft Convention adopted by the International Labour Conference at Washington in 1919.) Special legislation has been issued in Germany (Regulations for Pottery Factories in regard to Chromo-lithography, 1 January 1923). Special regulations exist also in the United States: States of New York (General Factory Law: removal of dust by exhaust apparatus in the pottery industry), New Jersey (prevention of lead poisoning in pottery factories, etc.: Standard Regulations for removing dust generally in the Manufacture of Pottery, 15 September 1919), Ohio (prevention of occupational diseases, October 1919; Pennsylvania (prevention of occupational diseases, July 1913); in Finland (Regulations of 30 December 1925); in France, Regulations relating to white lead (1 October 1911) were also applicable to workrooms for pottery decoration. In Great Britain the Pottery Regulations of January 1913 made under the Factory and Workshop Act, 1901, deal drastically with the prevention of dust, lead poisoning, and excessive weight carrying. As regards dust and lead poisoning, all known methods of prevention are utilised, e.g.: (1) substitution of innocuous for noxious materials — allowing dust-exposure from onerous and costly requirements as, for example, examination by the certifying factory surgeon, where leadless or low solubility glazes are used; (2) limitation of age; (3) monthly examination of lead workers, and (a) six-monthly examination of young persons and children engaged in carrying or lifting work, and (b) of china biscuit emptiers and scourers, and of females employed as wheel turners; (4) dust prevention either by locally applied exhaust ventilation or by use of damp methods; and (5) ordinary welfare requirements.

Definitions are given of (1) leadless glaze, and (2) low solubility glaze, as follows:

* Leadless glaze * means a glaze which does not contain more than 1 per cent. of its dry weight of a lead compound calculated as lead monoxide.

* Low solubility glaze * means: (1) a glaze which does not yield to dilute hydrochloric acid more than 5 per cent. of its dry weight of a soluble lead compound calculated as lead monoxide when determined in the manner described below; or (2) a glaze containing no lead or lead compound other than galena.

A weighed quantity of dried material is to be continuously shaken for one hour, at the common temperature, with one thousand times its weight of an aqueous solution of hydrochloric acid containing 0.25 per cent. of HC1. This solution is thereafter to be allowed to stand for one hour, and to be passed through a filter. The lead salt contained in an aliquot portion of the clear filtrate is then to be precipitated as lead sulphide, and weighed as lead sulphate.

The schedule of lead processes is as follows:

(a) Making or mixing of frits, glazes, or colours, containing lead.

(b) Dipping or other process carried out in the dipping house.

(c) Application of majolica, or other glaze, by blowing, painting, or any other process except dipping.

(d) Drying after the application of glaze by dipping, blowing, painting, or other process.

(e) Ware cleaning after the application of glaze by dipping, blowing, painting, or other process.

(f) Placing of ware on racks or similar articles prior to their transfer to saggars or kilns for the glost firing.

(g) Glost placing.

(h) Washing of saggars with a wash which yields to dilute hydrochloric acid more than 5 per cent. of its dry weight of a soluble lead compound calculated as lead monoxide when determined in the manner described in the definition of low solubility glaze.

(k) Preparation, or weighing-out, of flow material.

(l) Ground laying, including the wiping off of colour after this process.

(m) Colour laying, including the wiping off of colour after this process.

(n) Colour blowing whether on-glaze or under-glaze, including the wiping off of colour after either of these processes.

(o) Colour grinding for colour blowers.

(p) Lithographic transfer making.

(q) Any other process in which materials containing lead are used or handled in the dry state, or in the form of spray, or in suspension in liquid other than oil or similar medium; provided that the stopping of biscuit ware with a material containing lead shall not be deemed to be a process included in this schedule.

(r) Scouring of biscuit ware which has been fired in powdered flint.

(s) Emptying of biscuit ware which has been fired in powdered flint from
the baskets or other receptacles in which it has been conveyed to the biscuit warehouse or scouring shop.

Both leadless glaze and low solubility glaze factories are exempted from the requirement of periodic medical examination of lead workers. This is a considerable indulgence to manufacturers to adopt either the one or the other.

Where raw lead glaze is used, women and young persons are debarred from certain named processes. In all potteries no young person other than a male young person who wedges clay only for his own use is allowed to be employed in the wedging of clay, and no women without a certificate of permission to work. Similarly, no young person is allowed to be employed in carrying work without a certificate from the certifying factory surgeon specifying the maximum amount, and, with certain exceptions, no certificate can allow the carrying of more than 30 lbs. by anyone under sixteen years of age. No girl under sixteen is allowed to be employed as a lathe treater, and no young person as a dipper, and no girl under seventeen or boy under sixteen as a dippers' assistant or ware cleaner.

Somewhat similar restrictions are placed on women and young persons in glaze placing. Women are prohibited from carrying saggars full of ware.

Periodic medical examination. — In addition to the monthly examination of workers in lead processes, young persons engaged in carrying or lifting work have to be re-examined by the surgeon twice in the first period of six months, and once in each period of six months afterwards until they reach eighteen years of age. China biscuit emptiers and scourers also undergo a six-monthly examination. Results of examinations and permission to work is entered by the surgeon in a special health register.

Suppression of dust. — The following processes must be carried on under an efficient exhaust draught: fettling, sifting in powdered flint (unless done in effectively enclosed machines); batching of biscuit ware; glaze blowing; ware cleaning (unless done on entirely with the use of wet materials, or if the ware cleaning be done within fifteen minutes after the moment when the glaze is applied — the glaze scraped off, if not removed by exhaust draught, to fall into water); ground laying; colour dusting; colour blowing; making of litho transfers; removal from the saggers of biscuit flat ware bedded in flat; flat knocking and fired flat sifting to be done in effectively enclosed receptacles connected with efficient exhaust draught (unless so contrived as to prevent the escape of dust). Respirators are only required in emptying ovens, 125° F. is the maximum laid down for general purposes.

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Temperature. — A wet bulb thermometer is required in any workroom in which articles are allowed to dry, or in connection with which artificial heat is used, and the wet bulb must not exceed 70° F. except at such times as the reading of the wet bulb thermometer in the shade in the open air exceeds 60° F. In drawing ovens, 125° F. is the maximum laid down for general purposes.

The usual regulations apply in the case of overalls and head coverings, suitable accommodation for keeping and drying outdoor clothing, messroom accommodation for lead workers, washing accommodation and cleanliness of floors — daily cleansing by a moist method.

Special regulations apply to the lead house, dipping house, cleansing of boards on which dipped ware is placed (those used in lead processes to be painted red at the ends, etc.), majolica painting, aero-graphing (no short-sighted person to be employed unless wearing suitable glasses, as certified by the certifying surgeon).

Finally, a novel requirement is enjoined — self-inspection of the workrooms by a person appointed specially for the purpose, competent and fully conversant with the meaning and application of the Regulations. He is required to keep in the factory a book in which any breach of the Regulations or any failure of apparatus, and such steps as have been taken to remedy defects, are to be entered. Power is given to take samples for analysis.

The Pottery (Silicosis) Regulations of 24 May 1932 contain further preventive measures in regard to the protection of workers in certain processes from the risk of silicosis and include provisions concerning the wearing of overalls, ventilation, washing, the cleaning of workrooms, the avoidance of dusts, etc.

In the Netherlands, a Royal Order of 10 August 1929 contains regulations giving effect to the Labour Act of 1919, and contains, in paragraph 3 (sections 47 et seq.), provisions in regard to the work of women and young persons in the making of bricks, the preparation of clays, and the firing of bricks and tiles, the making of pavement slabs, and the covering of pipes in earthenware; paragraph 4 (sections 50 et seq.) contains provisions relative to factories and workshops where operations connected with the manufacture of articles are carried out (very detailed provisions).

In Norway the Royal Order of 30 October 1919 contains provisions in regard to hygiene in factories where lead compounds and other toxic substances are handled, and also provisions in regard to china, porcelain and earthenware factories.

In Russia the Compulsory Order of the Labour Commissariat, dated 15 July 1927, deals with the measures of protection to be taken in the pottery trade.

In Yugoslavia, Regulations of 25 October 1921 relative to hygiene and safety,
provide in sections 135 et seq., prescriptions relative to industries in which lead is used (section 142: "Pottery"); the operation of dipping with the bare hand in hot solutions of salts of lead, etc., is prohibited.

The International Association for Labour Legislation (Basle) for long studied this question, either in national committees or during its meetings. The Delegate Meeting held in 1910 (Lugano) decided to recommend to the Governments, by means of a petition lodged with the International Labour Office (Basle), the following recommendations relative to regulation of health conditions in the pottery industry:

I. The Governments should take steps towards the abolition of the use of lead in the pottery industry. To this end the following measures should be adopted:

1. In the manufacture of china and earthenware fired at a high temperature, the use of lead glaze should be prohibited.

2. As regards the manufacture of earthenware fired at a low temperature, a provisional list of articles should be drawn up which can, at the present time be manufactured without lead. This list, which would be subject to extension, should contain articles of common use such as pots, washing basins, dishes, mugs, bowls, etc., electrical insulators, etc.

3. As regards the manufacture of common pottery and plain stone tiles fired at a low temperature such as are manufactured on the Continent both in small workshops and in the workers' homes, litharge and red lead should be replaced by galena or any other less dangerous glaze. The preparation and use of unfritted glazes and the fritting process should be prohibited in such works.

The following measures would tend to encourage the gradual adoption of leadless glazes in the ceramic industry:

(a) The instruction and assistance of all occupiers in the industry wishing to make a practical trial of the use of leadless glazes;

(b) The strict enforcement of hygienic regulations in works using lead glazes.

II. Regulations for factories and workshops should only apply to establishments where leadless glazes are exclusively and permanently used. Factory inspectors should have power to take samples of analysis at all stages and at any time, samples of glaze and of the substances used in the preparation of the same.

1 Within the meaning of these provisions leadless non-poisonous glazes shall mean all compositions or frits used for glazing in the ceramic industry which contain not more than 1 per cent. of lead. Compositions containing no lead compound other than galena shall be held to be leadless. All other glazes shall be held to contain lead within the meaning of these provisions.

III. The following regulations should be adopted in the case of works using lead glazes:

1. The competent authorities shall have power to require, where necessary, the glazes used to be modified in order to prevent injury to the health of workmen employed in contact with the same.

2. The mixing, grinding and transportation of lead glazes as well as the lead used in their preparation shall be effected either in a thoroughly damp state or in apparatus which permits no dust to escape.

3. Frit-kilns must be so arranged that the molten frit can flow off into water, and frits must always be drawn off in such a manner.

4. Calcining shall be effected in a place separated from all the other workplaces, and exhaust ventilation in good working order shall be placed over the openings of the furnace.

5. Effective exhaust ventilation shall be applied in a suitable manner at all points where dust is generated such as the openings of grinding and mixing apparatus of transport apparatus, and of frit-kilns, and benches where glazes are applied in a dry state, where glazes of colours are applied by dusting, or where ware-cleaning is carried on.

All places where lead glazes or the lead used in their preparation are handled must be at least 3.5 metres in height, and 15 cubic metres of air space shall be allowed for each workman.

The floor must be impervious and washable, and the walls covered to a height of 2 metres, with a smooth and washable coating or paint.

6. No glazes shall be manufactured or used in living or sleeping rooms, and no lead glazes or lead used in their preparation or pottery covered with unfired glaze shall be brought into or stored in such rooms.

Where more than five persons are employed full time in an undertaking the said processes shall not be carried on in living or sleeping rooms or in rooms where other work is carried on, nor shall glazes, the lead used in their preparation, or pottery covered with unfired glaze be brought into or stored in such places.

7. On the conclusion of a suitable period of transition no female person shall in any circumstances be employed in any kind of work whatsoever which would bring her into contact with unfired lead glazes or compounds or with the lead used in their preparation. No male young persons under eighteen years of age shall be employed in such work except in so far as may be necessary for the purposes of learning the trade.

No young persons under eighteen or women shall be employed in any circumstances in the calcining process or in cleaning places where the above-mentioned substances or objects covered with
unfired lead glazes have been manipulated or stored.

(8) Hours of work shall be reduced for all persons employed in the processes mentioned in the preceding paragraphs in proportion to the dangers attendant upon the respective processes, and especially in the case of workmen in the calcining process, who shall not be so employed continuously.

(9) All workpeople employed in the manufacture of glazes containing lead as well as those who come into contact with raw glazes or the lead used in their preparation, shall wear special working clothes.

(10) The employer shall supply without charge a sufficient quantity of suitable working clothes, drinking and washing water, glasses, soap and towels. The employer shall provide for the washing of the said working clothes and towels.

(11) No person shall eat, drink or smoke in, or bring any food, drink or tobacco into, places where lead glazes or the lead used in their preparation are handled, or which are used for storing these substances or pottery covered with unfired lead glazes.

(12) The workpeople in question shall be examined every three months by a medical practitioner, appointed by the State authorities. The result of the examinations shall be entered in a register kept by the employer in the employment, which shall be open to inspection by the medical practitioner.

(13) No workman who is suffering from lead poisoning, or who has been found by the medical practitioner named in paragraph (12) to be unfit on medical examination by the medical practitioner appointed by the State authorities. The result of the examination shall be entered in a register kept for the purpose which shall be open to inspection by the inspecting authority.

(14) Two cloakrooms shall be provided, one for working and one for outdoor clothes, with a suitable lavatory and bathroom between the two. A mess-room shall also be provided.

(15) Employers shall give all workpeople contemplated in paragraph (9) on entering the employment, printed instructions as to the dangers of lead poisoning and its prevention, and shall affix such instructions in the workplaces.

(16) In the case of establishments using lead glazes so composed that the consequent risk to health is small, temporary exceptions from the preceding provisions may be allowed by the authority in exceptional circumstances.

In the Netherlands, diseases of the skin (eczema, dermatitis), as well as pulmonary diseases occurring amongst workers in the pottery trade, are subject to compulsory notification. Compensation for occupational diseases in this industry is usually confined to lead poisoning (France (decoration of china by the use of lead products in the pottery industry where lead enamels are used), Germany, Great Britain, Switzerland, U.S.S.R., in some states of the United States, etc. (see article "Occupational Diseases: Compensation ")) in Great Britain it also covers silicosis amongst workers in the refractory industries.

The problem of compensation for silicosis in the pottery industry was studied by a British Departmental Committee appointed in 1907 and reconstituted in 1957, as a result of which the Various Industries (Silicosis) Scheme was issued in 1928.

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Manufacture of Bricks and Tiles


TECHNICAL DATA

In this section will be discussed the technology and pathology of the brick and tile industry, including ordinary and ornamental tiles made of terracotta and earthenware.

This industry is, even at the present time, found in certain districts to be
carried on under primitive conditions, whilst in other centres it has been modernised and is effected with highly perfected automatic machinery.

For the manufacture of bricks, tiles and tiled flooring, the clay used is of a slimy consistency, being more or less pure clay. When the clay is too fat, it is mixed with sand or coke dust. The chamois yellow or red colour depends essentially on the composition of the earth used.

Manufacture is effected by hand or mechanically. The clay shaped by hand is dried in the open, firing being done in temporary kilns, or in fixed ovens, but always in an intermittent fashion. This primitive method is becoming more and more entirely replaced by the mechanical process, which involves the use of perfected apparatus (moulding machines, drying stoves, continuous kilns).

The principal processes in this type of manufacture are moulding, drying and firing. Certain products require supplementary operations such as pressing of bricks, flattening and cutting of square tiles, rolling of piping and varnishing.

Brick-making establishments only work during the six summer months, winter being devoted to the extraction of the clay. The relatively high cost of the raw material and the existence of small local factories.

While the kneading of clay with water and hand moulding on a bench are very tiring, work on the hearth tamped for the drying of moulded bricks, the operation of turning these from time to time, and drying them, building them into stacks is done in order to ensure free circulation of air between the bricks, constant supervision to protect them against unduly strong sun or from frost and rain, etc., are equally tiring operations.

The conditions of these workers, who, in certain districts (north of France, for example), form shifts grouped in certain working centres where they live and work for the time being, require attention on the part of factory inspection services in order to assure the existence of adequate living conditions, sleeping quarters and suitable working conditions.

It is true that modern methods are being introduced into this industry at an increasing rate, more especially on account of the difficulty found in recruiting labour for an occupation which involves such trying and difficult conditions.

The simplest means of mixing consists in cutting up the clay and kneading it by means of a curved knife after having watered it. At times, however, a special machine is used, worked by the arm and known as a "mill". In larger establishments vertical mixers are used, especially where the clay worked is soft. In modern establishments mixing is more thorough and comprises the use of several kinds of apparatus (mixing and rolling, even repeatedly).

The paste, after preparation, is subjected to shaping or moulding. The bricks, pantiles and flooring tiles of ordinary quality are moulded by hand on the moulding bench, by the use of a mould which consists of a wooden frame formed of four small boards. The piece of clay is introduced into this by the worker, pressed and smoothed with a damp plane. Immediately removes the mould and takes out the contents to the hearth for drying.

In mechanical manufacture the clay is first of all submitted to mixing in grinding and kneading machines, where plates and knives are arranged in such a manner that their rotation cuts into small pieces and kneads the clay, and thereafter pushes it towards an orifice, the diameter of which is more or less that required for the finished brick. The clay falls on an iron plate provided with a cutting frame, which on being lowered cuts out a certain number of bricks each time. This kneading machine may also be combined with a press, which subjects the clay to considerable pressure, transforming it into a solid mass.

Sometimes an impact press is used, which enables bricks to be manufactured directly the clay is extracted, without any preliminary operations.

Tiles and flooring tiles are manufactured by means of special frames and by an analogous process.

In mechanical manufacture moulding is effected by drawing the clay, followed usually by pressure in a mould. By imparting the desired section to the clay emerging from the perforated plate, bricks with special mouldings or ridges are obtained. Likewise hollow or perforated bricks are made by the use of perforated plates constructed for the purpose. For tile-making the drawing machine furnishes a flat band of clay, which is cut up into small cakes. In certain cases pantiles emerge from the drawing machine complete, so that it is no longer necessary to subject them to hand-shaping. For flat tiles the cakes of clay are submitted to pressure in moulds. Removing of edges is done by hand.
and the clippings are conveyed to a grinder for mixing with fresh clay. Flooring tiles and drainpipes are also manufactured mechanically.

**Drying** prior to firing is a delicate operation effected at ordinary temperatures or by artificial heat.

Natural drying at ordinary temperatures is adopted not only for handmade tiles but also in mechanically conducted brickworks. For artificial drying there are used either hearths which disseminate heat or aerocondensers.

Bricks, tiles, etc., are sometimes covered with an ordinary glaze to impart a more pleasing aspect to them. For this purpose there is used lead sulphide diluted in clay and water. Where black and opaque varnish is required, manganese dioxide is added to the mixture.

**Firing** is done in clamps or in intermittent or continuous kilns. Firing in clamps is only followed in the country. The best results are obtained by the use of intermittent kilns, in which firing is effected either by stratification or by a long flame. When a reducing atmosphere is brought about in the kilns after termination of the firing, a blue colour is imparted to the products. For artificial drying there are used hearths which disseminate heat or aerocondensers.

Flooring tiles and drainpipes are also manufactured mechanically. The problem is therefore a very delicate work. The kiln is lit after the formation of a few layers of brick only. The work of building up and finishing becomes extremely trying, because the lower rows of bricks must be already dried in order to support the weight of the later rows without marking. All the work is therefore effected in a hot and smoky atmosphere, containing a heavy proportion of carbon monoxide and sulphurous fumes. In calm weather such an atmosphere is almost irrespirable.

Special apparatus, for example that of Dubar and Baert, has been proposed with a view to hastening the building of the kilns by means of mechanical manipulation, involving diminution of the number of men or compressed air. The health risks to which the workers are exposed are in this way reduced. This apparatus also enables the dismantling of the kiln with less liberation of dust than the former hand method. Cinders from combustion constitute considerable annoyance for the workers.

The worker entrusted with firing keeps up the most favourable temperature for this purpose by charging the kiln from time to time with small amounts of combustibles, fed at short intervals through a large number of apertures. If the draught is insufficient during hot weather the kiln backfires, and the worker in charge is highly inconvenienced by gas escaping from the charging apertures. Even at normal times he is exposed to the effects of heat and reflection when he looks to the fire after each addition of fuel.

**Continuous kilns** have the advantage of permitting the greatest possible recuperation of heat loss. They utilise the calories stored up in the combustion gas for the gradual heating of freshly introduced products before they are submitted to firing, and enable use to be made of heat given off by the cooling of the fired products for preliminary heating of the air intended for combustion. There are several types of continuous kilns, the original type of which (Hoffmann kiln) has been provided with several improvements and alterations of importance.

Modern technical methods utilise types of kilns with forced draught, capable of putting to effective use the lost heat (for drying tunnels). In order to assure regular and perfect distribution of the fuel, recourse is had to automatic charging apparatus with utilisation of ordinary fuel arranged on the platform of the kiln. Attempts have also been made to utilise gas generators which send combustible gases for burning into the kiln.

Fired bricks, at the moment of removal from the kiln, should be sufficiently cooled to prevent the work of their removal being in any way trying for the worker engaged thereon. In practice, in the majority of cases, it is not so. If a ventilator is situated before the kiln door used for removal of the bricks, in order to accelerate cooling, a cloud of dust is raised from the deposit of dust on each brick handled. The problem is therefore a very complicated one, and it is essential to limit efforts to accelerating the passage of air through the fired bricks rather than creating a draught at the point of removal from the kiln. It has therefore been proposed to blow this air in through apertures in the hearth of the kiln, or to arrange in the vault of the hearth a number of beams, which would descend and separate the rows of bricks, thus facilitating the passage of air through the bricks to be cooled. These solutions of the problem are
hardly more satisfactory and the question still requires thorough consideration.

Compact qualities of pottery also include stoneware, which, thanks to firing carried to about 1,250° C. and sometimes 1,500° C. begins to undergo vitrification. The glaze used thus becomes hard, resonant and impermeable. Confusion between stoneware of this kind and artificial stoneware must be avoided, the latter consisting of a mixture of sand and lime treated with steam after moulding. A silica of lime obtained provides an imitation of certain kinds of stone.

Vitrification. A silica of lime is mixed with sand and lime treated with steam after moulding. A silica of lime is thus formed, so that the product obtained provides an imitation of certain kinds of stone.

For certain industrial purposes the stoneware to be manufactured has to be sufficiently refractory.

Materials made of dull stoneware are used for flooring tiles and paving stones, and certain tiles for facing buildings. The clay is mixed with a certain quantity of brick debris or terra-cotta, or white sand, according to the product required. Certain clays may be fired into stoneware naturally without being melted, but for certain other products there has to be added, on the other hand, slag from blast furnaces, felspar, etc.

Manufacture comprises the operations of preparation (grinding, pulverising, mixing and kneading, drawing of the mixture and a second pulverisation before use), moulding, drying and firing.

Certain products require to be fired in small saggers made of fireclay. The fired products are removed from the kiln, cleaned and stored. Pottery consisting of ordinary dull or varnished stoneware is used for making apparatus for chemical products, drainpipes and accessories, and various objects of domestic use.

Fireclay bricks are used in the construction of furnaces and especially for the inner lining of blast furnaces, Bessemer furnaces, etc., for metallurgical work.

There must finally be recalled Schist bricks composed of débris of coal schists coming from coal mines, and which are only utilised in the making of embankments.

Schists are employed alone or with the addition of fine clay. Two methods of manufacture are followed: work with dry paste and work with semi-soft paste. It is, however, necessary to break up and pulverise the schist in the first place, and this is done by the use of grindstones.

The schist prepared in this way is mixed, moulded and on emerging from the press is fired without undergoing drying.

Statistics

In the United States, A. Hamilton, in an enquiry covering 68 factories (1911-1912), met with 501 cases of lead poisoning (7.2 to 13.2 per cent.). Hayhurst in 47 factories (1914) only found (4.2 per cent.), whilst the Public Health Service in 1919-1920, during its enquiry covering 92 factories, revealed 270 cases (15 per cent.). It is worthy of remark that amongst the 300 cases assembled by Hayhurst, the investigators acting on behalf of the Public Health Service found that 40 out of 50 were still suffering from lead poisoning; as regards the other 59, no information was available except in the case of 24, 5 of whom had died.

In 1911 about 1,000 persons occupied in the tile factories were in contact with glazes in which lead was present in proportions varying between 5 and 20 per cent. (in most cases over 15 per cent.). The product in question was usually white lead. In the United States lead is not fritted, but added in part at least subsequent to fritting. For tiles and certain types of flooring tiles very high proportions are reached (50 to 60 per cent.). Trimming these tiles is extremely dangerous, because it is done dry, while in Germany and Great Britain this operation is performed in a wet state. The incidence of lead poisoning (1911) amounted to 15.1 per cent. amongst the men and 11.5 per cent. amongst the women. A comparison with the incidence in Great Britain is very striking:

<table>
<thead>
<tr>
<th></th>
<th>G.B.</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>1 : 113</td>
<td>1 : 112</td>
</tr>
<tr>
<td>Women</td>
<td>1 : 64</td>
<td>1 : 7</td>
</tr>
<tr>
<td>Total</td>
<td>1 : 69</td>
<td>1 : 19-11</td>
</tr>
</tbody>
</table>

Comparative mortality statistics have been prepared by the British Census Office. In general the figures for brick and tile factories prove that there are few occupations with such a low mortality (J. Latham). For the years 1900-1902 and 1910-1912, they were as follows:

<table>
<thead>
<tr>
<th>Occupations</th>
<th>All causes</th>
<th>Tuberculosis</th>
<th>Bronchitis</th>
<th>Pneumonia</th>
<th>Chronic Brights' disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick, tile manufacture, etc.: kilnmen and ovenmen</td>
<td>578</td>
<td>155.4</td>
<td>66.8</td>
<td>64.3</td>
<td>42.2</td>
</tr>
<tr>
<td>Other works occupied in the manufacture of bricks, tiles and pottery</td>
<td>1,243</td>
<td>175.7</td>
<td>131.1</td>
<td>97.4</td>
<td>37.8</td>
</tr>
<tr>
<td></td>
<td>All causes</td>
<td>Phthisis</td>
<td>Bronchitis</td>
<td>Pneumonia</td>
<td>Other respiratory diseases</td>
</tr>
<tr>
<td>----------------</td>
<td>------------</td>
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<td>------------</td>
<td>-----------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>All occupied or retired males, from 25 to 65 years of age:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1900-1902</td>
<td>1,044</td>
<td>137</td>
<td>58</td>
<td>97</td>
<td>27</td>
</tr>
<tr>
<td>1910-1912</td>
<td>790</td>
<td>141</td>
<td>37</td>
<td>67</td>
<td>16</td>
</tr>
<tr>
<td>Workers in the brick, tile and terra-cotta industry:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1900-1902</td>
<td>653</td>
<td>76</td>
<td>47</td>
<td>69</td>
<td>15</td>
</tr>
<tr>
<td>1910-1912</td>
<td>567</td>
<td>78</td>
<td>25</td>
<td>67</td>
<td>10</td>
</tr>
</tbody>
</table>

For 1921-1923, see note, p. 719.

Legge reported in 1900 on the mortality from phthisis or silicosis amongst workers making bricks and stoneware. He did not think it worth while to continue his enquiry until he had obtained accurate information as to the rôle played on the one hand by dust and on the other hand by the tubercular bacillus in the production of pulmonary diseases.

Microscopic examination of the lungs of the workers in the stoneware industry has revealed the close relation between tubercular phthisis and lesions caused by dust. Legge has insisted on the importance of determining the effect on mortality of lesions caused by dust apart from infection.

Sydney Smith and Collis have studied information as to the role played on the one hand by dust and on the other hand by the tubercular bacillus in the production of pulmonary diseases.

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The pathology of the workers in brick and tile factories varies largely in accordance with the methods of work followed. In fact, the introduction of mechanical and automatic apparatus has rendered this work much less tiring than was the case formerly when hand-work only was done.

German morbidity statistics provided by Gottschalck (1908) point to the predominance of rheumatism, particularly of a muscular type (lumbago). Under the former method of hand-presses, where the workers often worked barefooted and without assistance, the bending of the body required for stacking the bricks after manufacture, exposure of the workers to hot sunshine while perspiring from effort without adequate protection, rendered the work extremely trying. Hands and feet were often the seat of bruises and rhagades, facilitating the entrance of ankylostomiasis larvae when these were present in the soil of the brick yards. The Italian and German brick yards, etc., were infected in this manner a few years ago. Those in hot climates in particular are still affected and the disease from which the workers suffer is known under the name of "brick-workers' anaemia".

Erythema caused by sunlight, heat-stroke and dermatites are not rare amongst these workers. The transport of the clay, the operation of diluting it with water, kneading and even moulding it in certain countries is carried out by women and even by children, and their health, needless to say, suffers serious injury in consequence.

In small factories the glazing material is prepared on a hearth, without
draught and too often without any means of protection. The glazing medium is applied by means of a rag, applied to the object to be glazed, which is then dried in the air.

The risk of lead poisoning is very great in brickworks where primitive methods are followed.

The use of silica during moulding for preventing the paste from adhering to the mould gives rise to the liberation of large quantities of dust.

An enquiry carried out in 1926 by Sutherland and Bryson, in an English pottery where vitrified brick and ornamental tiles were made, has proved silicosis to be fairly widespread in this industry. Radioscopic examination of the workers in the workshop where the clay underwent the preliminary processes of preparation has proved the existence of silicosis amongst them. A similar result was shown by the examination of 6 men and 19 women engaged in moulding by means of a press. Six women, had had cases of tuberculosis in their families, 10 complained of difficulty in breathing and 11 of suffering from cough. Their physical condition was, however, good. Clinical examination showed 2 cases of fibrosis and 3 of bronchitis amongst the men, and 2 cases of fibrosis and of bronchitis amongst the women; 3 men and 1 woman showed signs of silicosis on radiographic examination; 3 men engaged in trimming tiles were likewise submitted to radiographic examination. The operation in question consists in rendering the tiles even and smooth, first by means of a hand grindstone, ultimately on a mechanical grindstone. Fibrosis, noted on clinical examination as affecting 3 workers, was not confirmed as such by radiography. The risk from silicosis in the manufacture of tiles is therefore extremely pronounced (see above, for air analysis and quantitative determination of dust contents). It should also be remembered that certain German authorities refer to a "brickworkers' aluminosis".

Tuberculosis, however, does not in general show a very high incidence rate, though Hoffman gives a percentage of 15.6, and in the case of 527 deaths attributes these in 82 instances to tuberculosis.

Digestive diseases (forms of gastralgia, gastro-enteritis, etc.) are in strict relation to the objective conditions (heat, humidity, etc.).

In certain countries — hot climates — noxious and parasitical diseases are fairly frequent: typhoid fever, helminthias.

Israelsohn (1927) has reported the occurrence amongst brickworkers of acute tenosynovitis of the muscles of the forearm, and particularly of the flexor muscles.

G. Blagovidoff (1925) has reported crepitant tenosynovitis of the wrist amongst moulders.

According to Mory, moulders suffer on commencing work from oedema of the hand, as well as tenosynovitis localised at the upper part of the radius.

Amongst certain workers the fingers and the hand become so swollen that they cannot close the hand or lift an object with the fingers. Other authorities, however, have not met with this type of lesion.

Women suffer from varicose veins, lesions of the sexual organs, miscarriages, etc.

In 1913 Legge, in response to a complaint lodged relative to the inferior quality of petrol utilised in brick-moulding, visited several brick factories and found that not only the bricks but also the entire surroundings of the process were impregnated with petrol. The workers suffered from intense eczematous eruptions on the arms, thighs and legs each time that the skin came in contact with a product or that the clothing became saturated with petrol. These troubles disappeared with the introduction of a product of better quality.

Similar but less serious forms of eczema have been met with in other brick works, using for the same purpose creosote oil. In one case an old worker showed eczematous ulcerations of the forearm which developed an epitheliomatous form necessitating surgical intervention.

**Hygiene**

For all operations in which lead is used reference should be made to the preceding part of this article: "Manufacture of Earthenware and China ".

Reference has been made above to the main technical improvements which can be introduced in regard to the manufacture of bricks and tiles (use of mechanical and automatic apparatus). Hand work should be as far as possible abandoned, for it is increasingly difficult to find workers ready to engage in such trying and heavy work.

The seasonal work requires the construction of temporary settlements, which ought to comply with legislative requirements (see article "Agriculture Labourers ").
Welfare measures are particularly essential when there is taken into account the nature of the work, in the open air, subject to atmospheric conditions, rendering the workers liable to contract all types of diseases connected with cold. For this reason it is necessary to provide adequate protective clothing, including waterproof footwear or clogs.

Special accommodation should be provided for clothing during working hours and facilities for drying it when wet. There should also be at the disposal of the workers messrooms with chairs or benches with backs, as well as facilities for heating food and boiling water. It is equally essential that there should be available a first-aid box and that restroom should be provided (for use in stormy weather, etc.).

It is, of course, essential that good drinking water should be provided. The transport of heavy loads by women and young children should be prohibited.

LEGISLATION

Legislation in regard to brick works is often included under regulations covering china and earthenware factories. It should, however, be recalled that young girls under sixteen are excluded from work in brick and tile works in Great Britain, that young persons under sixteen are excluded in South Africa from the processes of grinding and sieving raw materials containing not less than 80 per cent. of silica (SiO₂). The general aim of refractory materials and other processes is to prevent the effects of dust, either by damping by means of steam jets, or by localised ventilation, or by the wearing of respirators. The application of such legislative provisions is extremely difficult, especially in regard to the wearing of respirators in kilns, etc., for instance. The Regulations in question are therefore at present undergoing reconsideration (1927).

In Great Britain, Regulations covering the manufacture and decoration of pottery, dated 7 January 1923, set forth very detailed measures relative to the industry in question. In virtue of section 66 of the Act of 1901-1911, no young persons may be employed even in a workshop specially indicated by the said Act, without furnishing a certificate of fitness signed by a certified surgeon.

The Regulations of 29 April 1919, covering the operations of grinding and sieving of refractory materials and other processes involving their manipulation, apply to raw materials containing not less than 80 per cent. of silica (SiO₂). The general aim is to prevent the effects of dust, either by damping by means of steam jets, or by localised ventilation, or by the wearing of respirators. The application of such legislative provisions is extremely difficult, especially in regard to the wearing of respirators in kilns, etc., for instance. The Regulations in question are therefore at present undergoing reconsideration (1927).

In Belgium, the Royal Order of 15 February 1926 deals with the firing of bricks, and the Royal Order of 4 July 1925 with the hygiene and sanitation of the living quarters of workers engaged in brick manufacture. For other provisions, see also the laws referred to above in connection with china and earthenware factories.

In the Netherlands, skin diseases (eczema and dermatitis), cancer of the skin, cancerous tumours, pulmonary troubles, conjunctivitis, inflammation of the aponoeuses and of the sub-cutaneous cellular tissue, as well as ulcers of the cornea and of the conjunctiva, occurring amongst brick workers, are subject to compulsory notification. (For compensation, see above.)

In Great Britain, compensation of silicosis amongst workers in the refractory industries was provided by the Silicosis Acts of 1918-1924. At the present time this provision is incorporated in section 47 of the Workmen's Compensation Act of 1925.

Partial or total incapacity for work due to silicosis complicated by tuberculosis, or death certified by the medical office specially set up in execution of the law, are subject to compensation. (For details see article "Tuberculosis and Silicosis").

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PIERACCINI, in Ramazzini, 1907. Florence.

Sir Thomas Legge (London.)

Precious Stones


Precious stones or gems, those minerals sought after for their beauty and brilliance (colour, luminosity), as well as for their durability, are so varied and numerous that it is difficult to give a complete list. They fall into two groups: gems and hard stones.

Gems, or precious stones properly so called (diamonds, rubies, sapphires, emeralds, topazes, etc.), possessing in an eminent degree the above-described characteristics and not found in abundance in nature, are usually employed with rare metals for adornment (jewellery). Hard stones (amethysts, lapis-lazuli, malachite, etc.), which are found in fairly abundant quantities, are generally less hard and less opaque than gems. They are used for the manufacture, not only of jewellery, but of various other objects.

Precious stones are characterised by their specific gravity, generally exceeding 2.5, by their hardness (measured on the Mohs scale), their index of refraction, their chemical composition, which varies but is sometimes sufficiently well known for their artificial reproduction.
Artificial precious stones possess the same constitution and characteristics as natural precious stones, from which it is difficult to distinguish them with the naked eye. Industry can make hyacinth-stones, rubies, corundum, emeralds, sapphires, garnets and topazes; also microscopic diamond crystals.

Imitation precious stones are produced in the glass and crystal industry and are made of special types of glass or crystal (strass or paste to which bismuth or thallium is added) which may be colourless or have added to them certain metallic oxides for colouring.

Industrial Processes

Precious stones, properly so called, are reduced to a regular size, with plane or curved surfaces varying according to the nature of the stone, its proportions and the current fashion. They are then sawn by steel threads or metals discs dusted with diamond powder, and polished with a mixture of water and diamond dust (facets) or hard emery powder for softer stones.

The working of hard stones, generally by means of grindstones, is often a home industry carried on in small country workshops. According to pre-war authors, workers reclining on hollow semi-cylindrical wooden benches were in the habit of holding the stones to be polished against the grinding wheels by pressing against the bench with their feet. Often two polishers were engaged at each grindstone, one on each side.

Prior to polishing, it was the custom to groove, by dry working, the surface of the grindstone to the form of the object to be polished. After polishing, the grindstones had to be readjusted each time. These processes are now falling into disuse, for extension of the use of mechanical power has transformed the type of apparatus employed. Workers at present sit in front of the polishing stone instead of reclining on benches.

Only the manufacture of rubies has at the present time acquired any degree of industrial importance.

Sources of Risk

Cutting of precious stones up till quite recently has involved exposure to the risk of lead poisoning — use of grindstones or of lead "dops" — to the inhalation of dusts sometimes containing lead or other toxic or harmful products. For instance, the operator, in order to see the facets better is in the habit of rubbing them against the palm of his hand rather than cleaning them with a cloth, with the result that particles of lead are subsequently absorbed when he carries his hand to his mouth in eating or smoking.

In cutting establishments for precious stones, even managers are exposed to these risks, and many have been the victims of lead poisoning, often with fatal results (Talsky). Certain authors state that the making of "dops" exposes workers either to lead fumes or to smoke from stoves. At the present time, the use of carborundum, iron, copper, etc., grindstones, and the elimination of "dops" of tin or of lead or other constituents has resulted in the almost total disappearance of this source of injury. When metallic alloys are melted especially in domestic workshops, by means of coal stoves, the workers are exposed to the risk of carbon monoxide poisoning.

In cutting shops for hard stones the risk arises from mineral dusts liberated during dry cutting of grooves on grindstones, and during the polishing of the stones (crushing, cutting, polishing, piercing of holes, etc.). These types of dusts, which are extremely abundant, have a mainly mechanical action causing violent irritation of the accessible mucous membranes, especially those of the respiratory passage, and penetrate readily into the pulmonary tissue.

Under the older method of working, the worker lay on his stomach on his bench. This very tiring posture caused compression of the thorax and abdomen. In order to keep the stones in contact with the grindstones, the worker was obliged to exert an effort with his limbs and in certain cases with his whole body. When polishing large objects, the worker pressed his feet against blocks fixed on the flooring and pushed with all his strength. Finally, he was continually looking downwards to watch the work, which was tiring for the head.

When polishing is done by the wet method on a large grindstone, the head, neck, arm and chest of the worker are, because of their proximity to the grindstone, continuously subjected to a spray of dust, water and mud. Despite the use of means of protection (clothing, headgear, cloths) the clothing and the body are often soaked.

The floor of the workroom is often wet, even at a distance from the grindstones, and the humidity of the
surrounding air renders heating of the workrooms necessary even in summer.

Finally, polishing on grindstones demands, especially in the case of large objects, a high expenditure of energy. According to his strength and his habits, the polisher remains in the forced posture half-an-hour, one hour or even two-hours, until a sensation of fatigue in the chest and abdomen compels him to rise and take a rest.

**STATISTICS**

The statistics available are relatively few. According to those of Sommerfeld for the district of Birkefeld, relating to the period 1910-1912, the tuberculosis mortality rate per 100 deaths from all causes was 13.51 for agricultural districts and amounted to 25.38 in districts where polishing of precious stones was effected.

General mortality from all causes for the whole population varied in the district in question between 10.81 and 16.32 per thousand.

If the tuberculosis mortality rate be examined, it will be found that for the whole district of Birkefeld it was 27.15 per 100 deaths from all causes, 15.96 only for workers engaged in agriculture but 37.7 for industrial workers. The average age at death for the two latter groups was above 55.4 and 37.6.

Amongst polishers of precious stones, out of 35 deaths 37 were due to tuberculosis (67.08 per cent.) and 18 to other diseases (32.91 per cent.). From the fact that during the same period deaths from tuberculosis in the industrial district in question amounted to 37 per cent. and from other diseases to 63, Sommerfeld considers that the high tuberculosis mortality of this industry may be ascribed to working conditions, since amongst polishers in the Birkefeld district it exceeded by 30.09 per cent. the mortality for the general population.

**PATHOLOGY**

The injuries reported are to be explained by the dangers inherent in the materials manipulated and by the unfavourable conditions under which the work is often executed. These injuries are chiefly lead poisoning and pulmonary tuberculosis. The latter is caused not only by the action of dust, but also by the working posture, which often leads to stasis of the portal system in consequence of pressure on the lower part of the stomach and interferes with circulation in the lungs, already unfavourably affected by defective pulmonary ventilation.

Bad conditions, defective installations, dampness of the workrooms favour the outbreak of general troubles, chills, respiratory catarrh, rheumatism, nephritis, etc. Mention should likewise be made of general fatigue due to forced posture during work, as well as ocular and nervous fatigue occasioned by the close attention required during polishing.

**HYGIENE**

In certain regions in Germany (Oldenburg), stone-cutting establishments are subject to special legislative regulations: impermeable flooring in the workrooms which must be smooth and free from grooves in order to permit of ready cleansing. The same holds good of the pits in which the grindstones are fixed. Raw materials, scraps and residues must be kept in the workroom in special closed-receptacles.

The walls and ceiling of the workrooms must as far as possible be smooth and washed at least once per annum. Workrooms should be constructed in such a way that opening of doors and windows permits of adequate renewal of air during rest periods.

The flooring of the workrooms must be maintained in a constant state of cleanliness, and likewise the apparatus and machines used for cutting, crushing and sawing of stones. Recent developments in technical methods have certainly improved the precious stones industry and made it healthier.

The increasingly extensive use of grindstones made of carborundum, copper, iron, box wood, etc., and the replacing of lead "dops" have eliminated the risks of lead poisoning. Finally, the transformation of domestic workshops into factories represents an important hygienic improvement, since all adequate measures are enforced for eliminating dust (wet polishing, exhaust ventilation, etc.) and for ensuring personal hygiene (working clothes, seals, washing accommodation, etc.).

Amongst the legislative measures there should be mentioned the Order issued by the State of Oldenburg prohibiting the employment of young persons under sixteen years in the crushing and polishing of hard stones (agate).

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Primers or Percussion Caps


DEFINITION

A primer is a preparation capable of ignition when struck or rubbed or brought into contact with an electric spark, thus causing the detonation of a cartridge or charge of explosive material.

INDUSTRIAL PREPARATION

Most primers have a fulminate of mercury basis (see that article). There are various kinds of primers in use.

Harmless primers, such as used in toy manufacture, generally consist of a basis of fulminate of mercury agglomerated with a small quantity of gum and water. A small quantity of this is placed on a square of red paper (8 sq. mm.) and covered with a thin sheet of paper of the same size. Such primers detonate at the least shock and may also be made of red phosphorus and chlorate of potassium.

Primers for shooting and sport (hunting) have a fulminate of mercury basis. They are composed of a little tube of red copper, 4-5 mm. in diameter and 5-6 mm. high, at the foot of which is place 20-40 mg. of fulminate of mercury, according to the use to which the primer is to be put. The fulminate is then covered with a very thin layer of gum-lac in order to preserve its humidity and keep it in place. Sometimes the fulminate is mixed with 25-40 per cent. of powdered saltpetre to augment the ignition flame and diminish slightly the instantaneousness of combustion. The addition of nitre attenuates the shattering effects of the fulminate.

Primers for dynamite are of copper, 4-5 cm. in diameter, 30 mm. long and open on one side, with a charge of fulminate of mercury at the foot, varying according to the use for which the primer is intended.

With ordinary primers the explosion is caused by shock, but with dynamite primers ignition is caused by a mine fuse or Bickford fuse.

In electric primers ignition is due to a spark from an electric current used for mine explosion at a distance to avert danger to the operator. The older type of platinum wire primers are based on the principle of the incandescence of the platinum wire by an electric current, the wire being plunged into a charge of powder to cause ignition. A fusing composition causing the ignition of a fulminate capsule is fixed in the mouth of the primer.

Small arms factories usually restrict themselves to filling caps and primers, but do not manufacture the fulminate themselves.

HYGIENE

The fulminate may be made into charges for the percussion caps in a dry or a moist state and the latter system is preferable since it eliminates risk from dust. Such great precaution, however, is required throughout all stages of the work to prevent accidental explosion where the fulminate is handled in a dry state that these very precautions, demanding strict avoidance of dust, good ventilation, scrupulous cleanliness, and segregation of processes, etc. (see Dangers, article "Explosives"), reduce to a great extent the risk of poisoning. For this reason additional contact with the powder is reduced to a minimum and only occurs in initial weighing and mixing (with potassium chlorate, etc.). Weighing charges, loading and pressing can be so arranged that a man behind a heavy steel or thick concrete barricade can control the mechanism by a lever, guiding himself by watching a mirror above the machine. Other substances added to the charge—chlorate of potash, antimony sulphite, ground glass, or sulphur—are not harmful. Exposure to dust where such occurs causes fulminate dermatitis (known also as fulminate itch) chiefly among workers engaged in weighing, loading, pressing and inspecting primed shells. In certain arsenals the men are given carbolised vaseline to anoint the skin after washing. An ointment made of balsam of Peru with zinc ointment and a little carbolic acid is also used.

Workrooms in which fulminate caps, for toy pistols are made should be isolated from dwellings and constructed of light material. Explosive and inflammable material should not be stored in the workroom, but taken as required from the magazine. A limited stock of primers only should be kept in the magazine. Heating apparatus for the drying rooms should be placed on the outside of these and as far away as possible. Steam heating or hot water pipes should be installed. Still more rigorous measures are necessary for the manufacture of
primers for shooting, sport, etc. (see article "Explosives"). Panes of window glass should not be used, but should be replaced by white oily paper. The fulminate of mercury should be kept under water till required. Granulation should not be done by a spatula but by the hand on a table covered with a leaden slab and surrounded by a sheet metal guard of 11-12 cm. in thickness. The fulminate should be passed through a sieve outside the workroom, a hair sieve, furnished with lead plates at the bottom, being used. Very small quantities of the product should be handled at one time and the explosive mixture should be dealt with in a circumscribed space where accidental explosion of a charge would not endanger the whole staff. The workers should be protected as far as possible against accidental explosion. The charging rooms should be frequently cleaned and smoking absolutely forbidden. Daylight only should be utilised. The greatest precautions must be taken when cutting the sheet of paper covered with fulminate of mercury. (See articles "Fulminate of Mercury", "Explosives").

Printing Trades

French: Industries polygraphiques. —
German: Polygraphische Industrie. —
Italian: Industria poligrafica. —
Spanish: Industrias polígraficas.

In this article the pathology of the numerous categories of workers in the printing trades (composers, machine minders, lithographers, stereotypers, etc.) will be examined rapidly, but as completely as possible.

Printing had already been industrialised for three centuries since the invention of movable type when Ramazzini first drew the attention of scientists to some of the risks to which workers in this profession are exposed.

Although to-day the printing trade is amongst those which have benefited most by improvements in technical methods, it is nevertheless true that the morbidity rates for those employed remains, for complex reasons, fairly high.

Technical Data

Until recently, printing works were usually situated in the centre of towns to facilitate distribution, and often installed on the ground floors of old buildings. More recently, however, transport facilities have conducted to the building in the suburbs of large premises of one or more stories.

Further, while all the work in the older and smaller premises was done in the same workshop, modern printing works have separate workshops for the different processes (composing, printing, stereotyping, blockmaking, etc.).

The equipment of the composing room in a printing establishment consists of:

(a) single or double frames to hold the type cases. On the Continent the frames are often topped by shelves and pigeon holes. The case, in the form of a tray, is made of wood; it is about 14 in. deep and is provided with numerous small "boxes", each of which contains a particular character; the box is lined with one or more layers of thin cardboard to soften the slight shocks to the tips of the fingers when the characters are picked up; or the bottom of the box may be made of wire gauze with a drawer below to collect the dust. The work of cleaning the cases is thus facilitated, but in practice this kind of case is inconvenient as the metal base is either too rigid or too flexible and the characters easily stick to the wire, thus hindering the work of the compositor.

(b) The stone, on which the work is imposed, and randoms on which the composed work is placed before imposition or before the type is distributed. Standing type is sometimes kept in the lower part of the randoms.

(c) Shelves, to hold the "furniture" (wood or metal pieces, lower than the type, which serve to fill up blanks).

The implements used by the compositor are few, but characteristic of the trade, consisting of: composing sticks, tweezers and bodkins, and galleys.

The stick is the most important implement for the printer; it serves to hold the letters extracted one by one from the case to form the words and lines. It consists of a thin flat piece of metal usually about 10 in. long and 2 in. wide with flanges on the back and right hand side and on the left an adjustable slide which can be fixed to the particular "measure" or length of line required for the work in hand.

Tweezers and bodkins are used to facilitate manipulation of the characters on lines during correction.
The galley is an oblong tray to which the type is transferred from the composing stick.

Under the name of "type" are comprised all the letters used in printing. In a more restricted sense this term may be used to designate the entire collection of types of the same series and all the letters, spaces, etc., contained in the same case.

Type varies not only according to the form and size of the letter, but also according to the chemical composition depending on the proportion of lead (from 61 to 85 per cent.), antimony (from 15 to 33 per cent.) or tin (from 3 to 8 per cent.). The degree of hardness of the type depends on the proportion of antimony it contains, which may even amount to 75 per cent: in the case of very hard type. It must conform to a standard height, in order that the face may present a uniform surface.

Besides the letters there are dashes, punctuation marks, spaces and quads (for insertion between the words), which consist almost entirely of lead, a little tin, and at times traces of antimony.

The paper used in printing forms the subject of another article and will not further be referred to here.

On the other hand, printing inks require some mention. The ink used is a varnish composed of seccative oils and resin, mixed intimately with lamp-black so as to constitute a perfectly homogeneous black mass, clear and unalterable by air, drying rapidly, capable of impregnating the paper without penetrating it, of pleasant odour, and easily removed from the form and size of the type depend on the proportion of antimony it contains, which may even amount to 75 per cent. in the case of very hard type. It must conform to a standard height, in order that the face may present a uniform surface.

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cribe the methods followed in Linotype printing. This machine does not furnish ordinary single letters, but letters cast together in the form of a "slug", or line of type. The machine effects consecutively the composition, the justification of the line, the casting of the lines in slugs and the distribution of the "matrices", i.e. the moulds into the edges of which the letters are cut. After final use the slugs are melted down for recharging the Linotype machine. This machine consists essentially of a keyboard similar to that of a typewriter, magazines containing matrices, casting apparatus, and a distributing system; an assembly box on which the matrices are arranged to form the lines, a mould the length of a line and some millimetres in height, which receives the quantity of molten metal required to form the slug and a metal pot to hold the alloy for casting the slugs. The metal pot heated by gas or electricity, or failing these, by a special petrol lamp, is closed by a cover provided with a pipe to remove the fumes from the molten metal, and an exhaust device.

The operator seated before his keyboard fixes the assembly box to the required length and composes his text by tapping the keys with his fingers, as with a typewriter. Each key pressed brings down from the magazine the corresponding matrix, which arrives in the assembly box. When the key for the space is touched, it brings down a double wedged spaceband, and several of these, when the line is completed, automatically effect justification. The line, once composed, the release of the slug from the matrices and the distribution of these into the correct channel in the magazine is effected automatically.

Proofs are then pulled and sent for correction by comparison with the manuscript. The corrections marked on the proof are effected by the operator.

The next operation is to make the type up into pages after final revision by the author. The pages are so arranged that when the sheet is folded they fall into correct sequence. This is called "imposition" and includes placing the pages within an iron frame called a "chase"; the determined space between the pages is filled up with "furniture" about half in lower than the type so that it does not get inked in printing. The whole is then locked up in the "chase" by wedges or "quoins". At this stage it is known as a "forme" and is ready for printing.

Printing. — The forme then goes to the press — work that was formerly entrusted to the compositors, but is now trusted to the qualified workmen known as "machine minders" — operate numerous types of machine founded on the principle of pressure exerted by a plate known as a "platen" on a sheet of paper placed in contact with the surface of characters previously inked. Plates are of "light" and "heavy" types, set in action by treadle, though motor power is now usually employed. "Heavy plates" are of exceptional strength and are used for high-grade printing. Rotary machines, periodic or continuous, and rotary presses are used for printing a very large number of copies for which the pages must be stereotyped beforehand in the form of curved plates fixed on cylinders, between which the sheets to be printed must pass.

Special mention should be made of the ink rollers, which are made of a basic mixture of gelatine and molasses. An inked roller takes the ink from the feeding duct, whence it passes to a metal surface where uniform distribution is effected; the inking rollers take their supply from this disc and pass it on to the type.

After printing, Linotype and Monotype metal is sent back to be melted down, while all movable type is "distributed", an operation which consists in replacing the type used in the appropriate boxes. This is usually done by a compositor and is light work. In the case of hand composition, after having cleaned the type to be distributed with a brush dipped in lye, the compositor takes in the palm of his left hand a handful of lines, which he keeps in position with his thumb, while with the thumb and index finger of his right hand he takes the letters, which with a movement of the thumb, index and middle fingers he replaces in the appropriate boxes.

Stereotyping. — Stereotyping comprises the preparation of duplicate plates of type large relief printing blocks. The plates allow successive copies to be printed, thus releasing the type for other use. Use of the plates is essential in work on rotary machines. The plate is prepared by taking a mould of the forme on a sheet of "papier maché" or an superimposed sheets of paper, between which paste size mixed with Spanish white is spread. Into this mould, dried flat for an ordinary plate, or on a cylinder for a plate intended for a rotary machine, is poured the molten metal in order to obtain stereotyped
plates to serve for printing. These plates may of course be prepared by the alternative process of electrotyping (for the preparation of blocks, see article "Photo-engravers").

Lithography. — Lithography is the art of tracing, by means of a greasy substance on a special stone, characters or drawings with a view to their reproduction by printing. The reproduction may be black or coloured. The raw materials used in the industry of lithography may be subdivided into three groups: (1) raw material used for support; (2) raw materials properly so called; (3) accessory raw materials.

To the first group belong the natural stone or the artificial stone made of zinc, aluminium, etc. The natural stones are of different kinds: a bluish stone (the hardest), a yellow stone (soft), a slaty grey (medium), white, reddish grey, etc. The fairly high price of natural stones has given rise to the manufacture of various artificial stones, but none of these is equal to the natural.

To the second group belong the inks, the crayons for drawing and writing, the lithographic inks for copying or, for transfer, the inks and colours for printing, and the tracing paper, printing paper, etc. Lastly among the accessory materials figure various acids, notably nitric acid, spirits, and certain chemical substances, sponges, pumice stone, sealing wax, etc.

Lithographic work properly so called is done directly on the stone by means of a lithographic crayon or lithographic ink, by pen or pencil or by the method of transfer, by the aid of which the lines drawn on paper are transferred on to the stone.

The drawing may be transferred to a zinc or aluminium plate instead of to a stone, a method which is said to yield superior reproduction of fine tints. The same method is used, except that the acid solution is weaker than in the case of transfer to stone. The drawing is placed in a "damp book" consisting of damp blotters with a rubber cover. After twenty to sixty minutes it is removed and dropped on to the stone or plate, being covered with "backing" — a clear sheet of paper and a sheet of compressed and greased fibre-board — and run through the press. Special transfer paper requires to be soaked off, but ordinary tracing paper can be pulled off without further treatment. The stone after drying is then treated with gum arabic and nitric acid, or the zinc plate by gum arabic, chromic acid and phosphoric acid or the aluminium plate by gum arabic and phosphoric acid. The acid eats away any invisible particles of grease and does not affect the drawing itself, and the gum arabic desensitises the surface not drawn on. After drying, the surface is washed with clean water, sponged with a solution of gum arabic, rubbed down and dried, in the case of a plate the acid solution being washed off without drying. The stone is again washed with turpentine leaving the drawing invisible and rinsed with water on a sponge. The printing ink is then applied with a roller covered with leather, the stone or plate resting on the bed of the press, and prints are pulled by the application of sliding pressure.

Making of ledger. — Ruled lines on paper may be more or less complicated according to what the paper is intended for. Ruling may be "continuous", simple or uniform, or "discontinuous"; the lines vertical, horizontal, in different colours, etc. Formerly, and even at the present time, the system of ruling by means of a pen machine was used.

In modern technique disc machines are employed, some simple for ruling continuous lines, others complicated allowing for desired breaks in the tracing of various lines and for discontinuous ruling.

The black lines, the titles and the headings to the columns are set up in the composing room; the coloured lines are made by means of different inks with a basis of Prussian blue, indigo, aniline, etc.

Slachovský (1924), after making an enquiry into the aniline colours used in the making of the ledgers stated that "Water Blue Z III" only set up cutaneous lesions, that "366 Brilliant Green extra Krist" acts injuriously if it comes into contact with the mucous membrane and that "56 Methyl Violet" injures the skin and may cause injury when absorbed internally.

Stitching and binding. — The sheets of paper after printing and folding are next sent to be stitched. This is increasingly done automatically by machines. But in many workrooms stitching is still done by hand or at least partly only by machinery. Pamphlets are stitched by machine with galvanised steel or brass wire. The machine cuts the wire and forms it into hooks, bending the two ends. In the case of bound books, the machine stitches the book with a thread and binds the parts together, surrounding with the thread strips attached to the back of the volume, which is then brushed with
strong glue. The pages of the volume are then cut even; sometimes the edges are coloured or gilded; the back is then rounded by machine, and the volume goes to have its cover put on, the two halves of which are bound to the body of the volume by means of additional strips and bands of cloth. All this is glued inside on to the cover. The back is next made up of pasteboard, rounded by machine and stamped and the whole covered with a piece of cloth. The external covering follows — applied with strong glue — next the finishing, the title, etc.

**Sources of Dangers**

The printer's health is exposed to many risks. First, the working conditions may not comply with the requirements of hygiene, as, for instance, small rooms with insufficient cubic space, and inadequate ventilation. Further, either the natural or artificial lighting may not be satisfactory and it is a fact that eye troubles are rather frequent among readers, compositors and lithographers. The kind of work, involving a relatively stationary position may be harmful to the worker during cold weather if the room is not sufficiently warmed. On the other hand, the means of heating under conditions unfavourable to health (by stoves) provide another source of danger.

Moreover, the standing position and the attitude assumed may injure the worker, especially in the case of compositors of weak constitution; long continued standing may induce flat-foot, varicose veins and ulcers of the legs. The tools may cause skin lesions and give rise to trade calllosities. Manipulation of the characters either by hand or machine is a serious cause of danger; hand compositors are exposed to the risk of lead poisoning and the toxic action of the antimony which enters into the composition of alloys. In the case of typefounders, harmful gases may escape from the melting pot and become the vehicle of lead and arsenic, the latter being sometimes present as an impurity in the antimony used.

The Swiss National Accident Insurance Fund in Lucerne asked Professor E. Waser to analyse the air coming from the metal pots of composing machines as to its contents in lead oxide, paying special attention to the pots heated by electricity. While the formation of lead dust in the workrooms cannot be altogether avoided, so far as relates to the melting pots, Waser came to the same negative conclusion as previous research workers (Roth, Leymann, Carozzi, Heise, Froboise, etc.), namely, that the air above the metal pots of composing machines contains no lead and the amount of lead dust in this air is remarkably small. He did not consider it necessary to provide ventilating pipes over the metal pots heated by electricity as no fumes were given off.

The radiant heat, particularly from the composing machines, is yet another factor causing inconvenience to the worker.

Cleaning type cases raises toxic dust when carried out without due precautions.

The use of various liquids for washing the characters, machines, blocks, and the use of various solvents for the inks (xylene, benzene, alkaline solutions, petroleum, formalin, etc.) also increase the risks run. A recent process known by the name "Pantone", especially used in England, employs a paste with mercury as a basis for cleaning silver typographic plates as well as for typographical operations. Mercury fumes may be given off from this paste at room temperature and thus constitute a source of poisoning (Koelsch).

The basic substances entering into the composition of coloured ink, notably chromates, vermilion, mithium, etc., may also affect the health of the workers when not manipulated with care.

Lastly, injuries, especially to the hand, are common among compositors, pressmen, printers and inachinists.

**Statistics**

Although the morbidity and mortality figures of the printing profession have been studied for many years past both from the point of view of general causes of ill-health and causes peculiar to the trade, the first important study systematically carried out as a result of numerous observations and population data is that of Carozzi (1910). It embraced the whole of the printing trade in Italy, with special reference to the city of Milan, over a period of a year. His conclusions have been confirmed by later investigations in many towns and countries (Raneflett, Rome; Hoffmann, in the United States; recently Seitz in Saxony; Schwarz in Germany, Bradford Hill in Great Britain, etc.).

Fuchseine oxidised by arsenic acid is more brilliant than that produced by nitrobenzoal. It appears that makers are now again using arsenic for inks. In certain typewriter ribbons as much as 5-15 mg. per metre has been found.
Carozzi showed that the average morbidity from all diseases among printers (compositors and machine minders) was notably higher than that of other industrial groups taken as a whole.

Diseases of the digestive system were the most frequent, if not the most severe, followed closely by diseases of the respiratory organs. Pulmonary tuberculosis seems to bear a relation to the poor conformation of these workers. Together with bad conditions of work and the prevalence of lead poisoning among these workers, the same is true of neurasthenia, which is widespread in the industry and is due to a variety of causes.

Nutritional maladies, although by no means specific to this class, merit special attention because their frequency is out of all proportion higher than that of other industrial groups considered as a whole. In Saxony, Seitz found a relatively high mortality among the various categories of salaried officials, which made him consider that conditions of work were sufficiently satisfactory. On the other hand, at Leipzig 43.5 per cent., at Chemnitz 23.5 per cent., and at Dresden 25.5 per cent. suffered from headache and gastro-intestinal troubles. In these three cities about 8.5 per cent. had suffered from lead symptoms; but Seitz insists on the fact that the complaints were mainly subjective.

The mortality figures are the direct consequence of the high morbidity affecting mainly the group between sixteen and thirty-five years of age. Pulmonary tuberculosis (very high both in the acute and the chronic form) dominates the picture, together with acute and chronic respiratory troubles and infections. Carozzi considers this due to the lack of good physique among those who take up the trade. Generally speaking, they are feeble, physically defective and would certainly be rejected by thorough medical entrance examination. It should be added that under the conditions of work that prevail to-day the physique of young persons is better, which explains the slow but constant increase in the average duration of life among these workers as shown by statistics.

Carozzi also investigated the infantile mortality among printers and showed that it and miscarriage reached a high percentage (36.2%).

Comparing these data with those collected by Hamilton, Hoffmann, Seitz, Raneletti and with statistics furnished by Great Britain, the Netherlands and Austria, Carozzi was able to show that it was also high in the United States (35 per cent.), in Great Britain (31 per cent.), in Berlin (48 per cent.), in the Netherlands (18 per cent.), etc.; and further enquiries conducted in those countries showed that the most frequent cause of death was due to respiratory and digestive diseases, from gout and rheumatism, and from nervous diseases. Less high were the figures for lead poisoning (in its recognised clinical form), which constituted only a slight addition to the pathology of the profession.

There will here be given but a brief summary of the enquiries published during recent years.

In Germany, according to information furnished by the Printers' Union for the year 1929, the total number of cases of sickness was 39,400, which accounted for 1,124,929 days of illness. Of the cases noted, in the order of frequency, were infectious diseases, 9,175; respiratory diseases, 4,070 (of which 888 were pulmonary); nervous diseases, 3,635; digestive, 3,427 (of which 1,827 were gastric); tumours, 2,752; gout and rheumatism, 2,318; circulatory diseases, 1,988; diseases of the generative and venereal organs, 871; saturnism totalled 349. The number of deaths totalled 795, of which 93 were due to diseases of the lungs, 64 to pneumonia, 10 to heart disease, 34 to diseases of the intestine, 24 of the arteries, 39 of the kidneys, 14 from tumours, 13 from diseases of the liver, and 7 from lead poisoning.

Per 1,000 members the number of cases of sickness was 250 in 1920 (of which 48 were due to respiratory diseases, 20 to nervous and 23 to digestive); of 246 in 1924 (of which respectively 30, 29, 38); 378 in 1928 (of which respectively 46, 46, 41) and 402 in 1929 (of which respectively 47, 40, 29).

Statistics show that it is between the ages of fifty-one to sixty-five that death claims its largest tribute. As compared with 258 deaths at this age group, 160 occurred in the age group 36-50 and 116 in the age group 21-35 years. For the age group 18-20 there were 9 deaths, and for the age group 66 and over, 252 deaths.

In Saxony, Seitz found a relatively high stability among the various categories of salaried officials, which made him consider that conditions of work were sufficiently satisfactory. On the other hand, at Leipzig 45.5 per cent., at Chemnitz 25.5 per cent. and at Dresden 25.5 per cent. suffered from headache and gastro-intestinal troubles. In these three cities about 8.5 per cent. had suffered from lead symptoms; but Seitz insists on the fact that the complaints were mainly subjective.

The cases of sickness based on the objective signs registered between 1 January 1922 and 30 June 1923 among the members of the Sickness Fund of Saxony were distributed as follows:

<table>
<thead>
<tr>
<th></th>
<th>Composers</th>
<th>Machine minders</th>
<th>Casters</th>
<th>Stereotypers and casiers</th>
<th>Machine compositors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of members at the end of 1922</td>
<td>4,053</td>
<td>1,875</td>
<td>317</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Number of cases of sickness</td>
<td>668</td>
<td>487</td>
<td>58</td>
<td>308</td>
<td></td>
</tr>
<tr>
<td>Cases of sickness per 100 members</td>
<td>21.4</td>
<td>23.1</td>
<td>16.2</td>
<td>16.4</td>
<td></td>
</tr>
</tbody>
</table>
In 1929 Seitz extended his study of the physical and social conditions to cover all German printers. Unfortunately, he did this by means of a questionnaire, so that there was no serious control over the data received. Seitz received 41,778 replies (7,168 machine minders, 20,165 compositors, 1,798 proof-readers and workers engaged in making up the pages, i.e. stone-hands), of which 31,283 only were thought of value. The enquiry also covered housing, tuberculosis among members of the family, etc., and showed that 0.98 per cent. of printers were tubercular (in Bavaria Kolesch found 0.49 per cent., Leipzig Sickness Fund, 0.13 to 0.44 per cent.).

Hoffman's enquiry in the United States and Canada dealt with hygienic and sanitary conditions and was made by means of a questionnaire addressed to associations of employers and workmen. From the replies of 2,096 employers relating to the years 1922-1923, the number of sick persons among a body of 1,000,704 workers was 697, or a percentage of 0.69, the comparative lowness of which must be placed to the credit of the hygienic conditions of printing works in America.

The data concerning mortality were furnished to Hoffman by the International Typographical Union. In 1929 no death was attributed to lead poisoning, but the causes of death which might result from the action of lead (nephritis) are always frequent enough, although they too seem to be diminishing. The mortality per 100,000 members and for certain causes of death work out as follows:

<table>
<thead>
<tr>
<th>Years</th>
<th>Number of members (average)</th>
<th>Pulmonary tuberculosis</th>
<th>Tumours (cancer)</th>
<th>Diabetes</th>
<th>Nephritis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1912-1918</td>
<td>421,000</td>
<td>33.0</td>
<td>10.7</td>
<td>70.8</td>
<td></td>
</tr>
<tr>
<td>1919-1923</td>
<td>350,000</td>
<td>30.4</td>
<td>21.9</td>
<td>68.4</td>
<td></td>
</tr>
<tr>
<td>1925-1929</td>
<td>369,658</td>
<td>30.4</td>
<td>19.7</td>
<td>60.9</td>
<td></td>
</tr>
</tbody>
</table>

It is necessary to emphasise once again the fact that it is the age group 20-49 years that suffers chiefly from tuberculosis and respiratory diseases (pneumonia in particular) and that nephritis occurs amongst these workmen at a fairly early age (between thirty-five and fifty-four years).

As regards pulmonary tuberculosis, the following values from 100 deaths from all causes of each age group were found:

<table>
<thead>
<tr>
<th>Age groups</th>
<th>1912-1918</th>
<th>1919-1923</th>
<th>1925-1929</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>14</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>30-39</td>
<td>22</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>40-49</td>
<td>17</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Over</td>
<td>9</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>67</td>
<td>66</td>
</tr>
</tbody>
</table>

The percentage of deaths from tuberculosis at every age rose from 20.9 (1912-1918) to 14.9 (1919-1923) and 8.2 (1925-1929). The deaths from lead poisoning during the period 1914-1923 numbered 64, 8 of which were among workers in age group 18-30 years; 12 in age group 31-40, 23 in age group 41-50; 14 in age group 51-60 and 7 in age group above 60 years. An enquiry (1927) in the Philippines by Villafranca and Igasiano brought into relief the very high mortality amongst printers, attributed by them to long hours, lack of air space, work at night, work at high pressure, and lead poisoning.

In Great Britain the National Society of Operative Printers and Assistants shows for the period 1909-1922 640 deaths distributed as follows:

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Number of deaths</th>
<th>Pulmonary tuberculosis</th>
<th>Tumours, all forms</th>
<th>Pneumonia</th>
<th>Chronic nephritis</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>166</td>
<td>20</td>
<td>2</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>20-29</td>
<td>83</td>
<td>22</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>30-39</td>
<td>147</td>
<td>47</td>
<td>5</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>40-49</td>
<td>208</td>
<td>72</td>
<td>10</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>50-59</td>
<td>155</td>
<td>19</td>
<td>7</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>60-69</td>
<td>54</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Over</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>640</td>
<td>171</td>
<td>56</td>
<td>69</td>
<td>22</td>
</tr>
</tbody>
</table>

For the mortality from pulmonary affections the same Society gave the following figures from all causes for the same age group:

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Number of deaths</th>
<th>Pulmonary tuberculosis</th>
<th>Tumours, all forms</th>
<th>Pneumonia</th>
<th>Chronic nephritis</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>166</td>
<td>20</td>
<td>2</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>20-29</td>
<td>83</td>
<td>22</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>30-39</td>
<td>147</td>
<td>47</td>
<td>5</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>40-49</td>
<td>208</td>
<td>72</td>
<td>10</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>50-59</td>
<td>155</td>
<td>19</td>
<td>7</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>60-69</td>
<td>54</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Over</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>640</td>
<td>171</td>
<td>56</td>
<td>69</td>
<td>22</td>
</tr>
</tbody>
</table>
of the very high mortality from pulmonary tuberculosis. Like the previous authorities quoted, Bradford Hill attributes this mortality to the poor physique of those who take up the work and to unfavourable working conditions. With reason he stresses the importance of the problem under review for over 250,000 workers are engaged in the printing industries. By a comparison of the data as to 36,000 members from some nine printing associations with those furnished by Friendly Societies, Bradford Hill reveals the fact that printers show a high average of sickness and incapacity from the first years of employment onwards. For the age group 16-19 years the position is very unfavourable when compared with the general population: the same fact is brought out for tuberculosis, which, however, affects machine minders at a later age than it does hand compositors.

For Italy it is possible to present figures drawn from the very detailed statistics of the "Cassa Malattia Poligrafici" of Milan. During the period 1925-1927 this Fund received notice of 187 deaths, of which 42 were due to all forms of tuberculosis (37 pulmonary tuberculosis), 20 to respiratory diseases; 21 to diseases of the heart and blood vessels, and 126 to others, etc. The morbidity of members (male and female of this Fund during the same period showed the following values: number of cases of sickness, 30,955; number of cases of respiratory diseases, 1,471 (of which 105 were pulmonary tuberculosis, 79 alveolar bronchitis and 65 catarrh of the pulmonary apices); diseases of the stomach and intestines, 1,062; of the heart and blood vessels, 237; of the nervous system, 387 (of which 168 were cases of neuroses); of the kidneys, 104 (of which 47 cases were chronic nephritis).

Cagetti (1930) brings out the frequency of pulmonary tuberculosis as a cause of death: of 100 cases of death in the same occupational group during the period 1921-1925, compositors and lithographers showed the figure of 22.8 (the highest), followed by the workers in the metal trades 21.7; for masons and sailors on the other hand the figures were 9.2 and 9.3 per cent. respectively.

<table>
<thead>
<tr>
<th>Age groups</th>
<th>1910-1912</th>
<th>1912-1913</th>
<th>1925</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 25</td>
<td>36.4</td>
<td>32.9</td>
<td>33.3</td>
</tr>
<tr>
<td>25-34</td>
<td>43.5</td>
<td>32.5</td>
<td>40.7</td>
</tr>
<tr>
<td>34-44</td>
<td>31.8</td>
<td>29.3</td>
<td>19.8</td>
</tr>
<tr>
<td>Over</td>
<td>10.3</td>
<td>8.4</td>
<td>6.0</td>
</tr>
<tr>
<td>Total</td>
<td>29.9</td>
<td>14.9</td>
<td>8.9</td>
</tr>
</tbody>
</table>

The Registrar-General's Statistics for 1921 give the following particulars of printing operatives:

<table>
<thead>
<tr>
<th>Categories</th>
<th>Number</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men aged 20-65 years</td>
<td>10,082,062</td>
<td>278,911</td>
</tr>
<tr>
<td>Total persons occupied aged 20-65 years</td>
<td>9,701,860</td>
<td>266,384</td>
</tr>
<tr>
<td>Total printers, bookbinders, and photo-engravers aged 20-65 years</td>
<td>115,419</td>
<td>293</td>
</tr>
<tr>
<td>Total employers and managers</td>
<td>12,175</td>
<td>1.9</td>
</tr>
<tr>
<td>Total foremen and supervisors</td>
<td>24,729</td>
<td>32.5</td>
</tr>
<tr>
<td>Total hand compositors</td>
<td>7,288</td>
<td>32.9</td>
</tr>
<tr>
<td>Total lithographers</td>
<td>8,672</td>
<td>32.1</td>
</tr>
<tr>
<td>Total machine minders</td>
<td>16,267</td>
<td>32.5</td>
</tr>
</tbody>
</table>

By taking as 1,000 the mortality from all causes of all employed and retired persons between twenty and sixty-five years of age and comparing the figures of mortality due to various causes to those for the printing trades the figures in the table below have been obtained.

A very interesting study is that of Bradford Hill (1925), published by the Industrial Health Research Board (No. 54) relating to 32,969 persons, of whom 14,507 were compositors, observed over a period of five years. These data confirm the fact...
In the U.S.S.R., Bensman in 1925 studied the health condition of the workers in the printing industry at Krasnodar. His enquiry covering 328 workers, of whom 34 per cent. presented a more or less marked diminution in haemoglobin and 44 per cent. all stages of tuberculosis. Kaminski analysed 1,489 cases of sickness among printers in Kharkow and found that the number of days lost through sickness due to tuberculosis among hand compositors and machine minders (369 per cent. of the total days lost from illness, as compared with other groups in the same industry 17.3 per cent.) was very high.

PATHOLOGY

In Germany Seitz (1929) and in Austria Brezina and Lebzelter have undertaken enquiries into the physical state and constitution of printers. Lack of space unfortunately prevents summarising these interesting studies. Reference should also be made to the researches of Bargeron (1929) published by the Lannelongue Institute in Paris.

In addition to the maladies affecting printers in common with other workers, under the same environmental conditions (cubic space and area, ventilation, etc.), these, are others aggravated by the concomitant action of such conditions when defective, as well as by the action of lead, especially chronic or less intense anaemia manifesting itself in pallor of the skin and mucous membrane and a state of well-marked organic decline. Examination of the blood, however, merely reveals ordinary oligaeemia with predominance of oligochromaeemia; the white blood cells present a normal differential count, although the number is about the normal lower limit (Pieraccini). It is also possible to find punctate basophilia due to lead absorption (see below).

Insufficient natural lighting or, as is often the case, inadequate artificial lighting, reading difficult manuscript, the fineness of the work to be done, constant change in the position of the glance, as well as of accommodation, all favour eyestrain and explain the incidence of visual defects among compositors (diminution in acuity of vision, errors of refraction and accommodation and muscular co-ordination).

Among printers with eyestrain, Mosse succeeding in showing that vision was normal after Sunday rest and that visual troubles came on towards the middle of the week's work. For a long time Cohn and Hirsch have laid stress on the frequency of myopia among printers. Walther looks on this as an undoubtedly occupational disease, even where the presence of the existence of school myopia is recognised.

Hitzing has described among these workers, as well as among machine minders, a form of conjunctivitis which he attributes partly to irritation from the paper dust.

Occupational stigmata localised on the hands and caused by the tools are characteristic. In addition to a callosity in the palm, the right hand presents a callosity on the internal border in the neighbourhood of the metacarpophalangeal joint which is 2 cm. long and 1 cm. wide; two at the anterior face of the ball of the thumb and index finger (Chevalier and Vernois); another callosity is situated on the upper extremity of the line between the thenar and hypothenar eminences, due to the pressure of the composed lines when they are lifted by the compositor to be placed on the galley (Carozzi), and a fifth callosity on the internal border of the dorsal side at the level of the middle line of the palm, resulting from pressure from the page cord during tying up of the pages. Further, intensive and prolonged work, especially in winter, with the cord may raise the skin at the point indicated and set up painful fissures involving temporary incapacity for work.

Among compositors there is found rubbing away of the free edge of the nail of the right thumb, especially on the radial side, and this is even more marked on the nail of the index finger where the wearing away takes place at the cubital edge. The skin of these two fingers take on a dull hue very much more pronounced than that of the other fingers and the rest of the hand with formation of small flat callosities on the tips due to shock of these fingers against the little metallic cubes during manipulation of the characters. The colour of the skin is attributed to the alloy (Pieraccini and Casagli).

Eczea of the hands and forearms, hyperidrosis, etc., due to contact with irritant substances (turpentine, benzol, petrol, strong 1yes, chromates, etc.) are very frequent at the present time (Silberstein).

Introduction into lithography of the process of chrome reproduction has favoured the development of cases of eczea. An enquiry by Engelhardt and Mayer (1931) covering fourteen lithographic printing works and relating to 114 workers showed eczea present in 30, of whom 84 per cent. were hyper-sensitive to potassium bi-chromate; among the other 84 workers 7 only reacted to the sensitisation test.
The affected persons had ulcers on the septum, but without ulceration of the mucous membrane. Cases of eczema among these workers cannot be denied. In photo-mechanical transfer of texts and designs, bichromate of potash or ammonium is used mixed with organic substances (albumen, gelatine, gum arabic, etc.). Up till a few years ago the danger of eczema from chromates was considered of little importance, but for some years past, on the other hand, the process-engraving industries furnish a large number of cases (McCord, Higginbotham and McGuire, 1930). This incidence may be explained by the development of advertisement, of illustrated papers and rapid reproduction of pictures, etc., by means ofchrome processes.

In Great Britain, Overton (1929) conducted an inquiry in thirty-one printing works, examining nearly 150 workers engaged on lithographic processes and photolithography; about 7 per cent. of the workers were found to have dermatitis, due probably to chronic acid or chromium compounds used during the operations of transferring and lithographic printing. Paraffin and turpentine were also held responsible. An inquiry made by the German Union of Printers and Engravers affecting 9,400 persons employed in process engraving revealed the fact that in the first quarter of 1930, 202 cases of skin maladies were reported, especially eczema (101 of the patients suffered several times); 130 of these 202 cases attributed the condition to zinc mordants, chrome salts and other substances used in engraving.

Frequently in winter compositors suffer from rhagades (painful fissures), which easily become infected, for they correspond with the small callosities of the thumb and index finger already referred to involving long periods of incapacity from work. These lesions are said to be due to the action of the damp type and coldness of the premises during the winter months. As a result of these conditions liability to injurious effects from traumatism is heightened. They do not occur among workmen in dry and well-heated rooms (Pieraccini and Casaglì).

The printing profession does not demand forced attitudes or bad posture to an extent sufficient to set up marked alterations in the trunk and limbs. It is however, the compositor's posture before the type cases, with his back slightly bent, his head stretched forward or looking towards his manuscript, must exercise an unfavourable effect on the health (Oliver and Pieraccini).

The continuous swaying movement which is characteristic of the machine minder tending certain printing machines should be mentioned.

The constant standing position necessitated by the work in printing offices accounts for the fairly frequent occurrence of flat foot (about 57 per cent.) and varicose veins in the leg, associated sometimes with ulcers. These are favoured by hard weather and too long lead circulation, habitual constipation, and most often by the constitutional biological type and anatomical predisposition of the worker. Constant standing may also cause movable kidney and sometimes ptosis of the intestines which are fairly frequent among these workers: lumbago and cramps in the muscles of the back (machine compositors), pains and cramp of the thigh (hand compositors and machine minders, etc.).

Certain habits such as holding the type between the teeth, cleaning the type and cases by blowing on them to remove the dust, eating in the workshop without previously washing the hands, etc., naturally favour the penetration of poison into the system.

Several authors take the view that lead poisoning among those engaged in the printing trade is no more frequent than in other categories of workpeople handling substances containing lead. As a matter of fact the statistics given rather strengthen this view. According to A. Seitz, cases of saturnism at Leipzig reached the figures of 8.1 per cent. of the persons examined, and in the enquiry of the Union of German Compositors saturnism in 1929 showed a percentage of 0.89 cases of sickness. Data provided by Jehle, however, limits it to 1.92 per hundred printers (Vienna) and those of the Sickness Fund to 3.3. In Great Britain lead poisoning worked out at 3 cases per hundred printers, and at Milan Carozzi found 1.7 (8.6 for compositors alone) and Ranelletti, at Rome, 3.3 per hundred workers (4.1 per cent. of cases of sickness: with one case only among 539 machine minders and feeders, of whom 246 were men).

In 1927 Koiransky examined 512 printers for punctate basophilia in Moscow and found it in 13.3 per cent.; polychromasia in 8 per cent. The punctate basophilia showed itself especially among the hand compositors (15.8 per cent.), casters (15.8) and machine minders (15.2); among the stereotypers the percentage was only 4.2.

The lead and antimony which enters
The channels of entry are the same as for lead poisoning (see that article). In 1927 N. Sach, in an examination of 395 Russian printers, found that affections of the mouth were very frequent (more than 69 per cent.); he attributed them not only to the absence of dental hygiene but also to the action of the lead, because it is well known that abnormal conditions of the mucous membrane of the mouth facilitate the absorption of poison. Whilst the blue line has been found in 6.3 per cent. of the workpeople — 15.8 per cent. in the compositors and 7.5 in the hand compositors — colic only affected 0.8 and paralysis 0.6. But these conclusions do not mean that the risk of lead poisoning in the printing industry does not exist or is negligible. It only means that lead poisoning is not so severe among printers as among other categories (painters, engravers, etc.). In reality this form of poisoning almost always assumes a slight form affecting especially the digestive and circulatory systems, the liver and kidneys. Good hygienic conditions of the workshops on the one hand, the small quantities of metalised lead absorbed very slowly into the system on the other, explain why these are not sufficient to produce the characteristic clinical symptoms, but none the less they exercise an injurious effect, manifested by anaemia and a general lowered resistance favourable to the development of tuberculosis and by a series of symptoms (stomatitis, dental caries, digestive and nutritional troubles, etc.) spoken of as "petit saturnism" (slight saturnism).

There is no need to repeat what has already been said (Statistics) as to the very high incidence of respiratory diseases and tuberculosis in particular among printers.

It is difficult to admit natural selection, as certain authorities do (Bensman in particular), as sufficient to exclude those who are not strong from the printing industry.

The views of Carozzi, no longer of quite recent date but confirmed by other authorities, show that on the contrary it is the less vigorous who take up this trade; they are young persons of nearly average health, the victims of over-exhaustion, mental and physical, since very often in the evenings after their work they strive to study with a view to improving their position.

The Institute of Legal Medicine in Siena, directed by Bianchi, is taking up the study of occupational biotype and the first of these studies (Baisi, 1930) dealing with printers has been published. Although the enquiry relates to only a small number, the author believes that he has been able to show that those who enter this profession are especially individuals of a very feeble type.

The researches will perhaps show on which of the various categories of general constitutional type absorption of lead exercises its effect and will likewise reveal the relation existing between trade morbidity, occupation and constitution.

The absence of selection, the social origin often involving physical defect, the sacrifices that these workers make to improve their knowledge, the early age at which they enter the trade, the working conditions, the absence of movement and physical exercise and lastly the action of lead dust, all these conditions — even admitting an antagonism between lead poisoning and tuberculosis — represent causes predisposing to respiratory diseases.

Maladies of the digestive tract hold second place, taking the form of gastritis, dyspepsia, atony and obstinate constipation which some authorities attribute to the sedentary life, lack of movement, the necessity for resuming work directly after meals, a strained attitude; while others (Carozzi) regard
it as a slight form of lead poisoning especially in its preparatory phase.

This hypothesis finds confirmation in the verselet, while, into, who for a long time has reported on the frequency of gastric trouble in pre-saturnism, and in the clinical and anatomopathological findings which prove a saturnine origin for certain forms of enteritis in printers (Massini, Fabris).

Similarly, it is to the action of lead that derangement of the liver and of the cardio-vascular system is due, which, in order of frequency, follow closely the respiratory and gastro-intestinal maladies.

Latyscheff (1927) from an examination in ten of the principal printing works in Moscow of 1,200 workmen, of whom 88 were compositors, arrived at the conclusion that lead, in contra-distinction to other sympathico-tonic poisons, markedly increases occurrence of tubercular lesions; it affects the normal relations of the endocrine glands; causes, on account of the hypertonicity of the sympathetic system, secretion of hyper-acid gastric juice with increase in the content of acids and mineral and acid substances. Anaemia and nutritional diseases are most common amongst women as they are less resistant. This enquiry emphasises yet again the high incidence of saturnism in its slighter forms, affecting lungs, heart and digestive apparatus.

The pathology of the cardio-vascular apparatus is characterised by an increase of arterial pressure, by pathological alterations causing arteriosclerosis, by arteritis and organic heart changes involving the kidneys. The experiments and clinical investigations of Preti and Devoto of toxic arteriosclerosis have demonstrated the special action of lead on organic changes, an action causing a urio-acid diathesis, a condition extremely favourable to the development of cardio-vascular maladies.

To sum up, although it does not cause the classical signs, lead dominates the whole pathology of those employed in the industry, and prepares and predisposes the whole system to the insidious onslaught of different disease forms.

An etiological association between gout and saturnism (Pieraccini) is held by some and denied by other experts (Hahn), or considered doubtful (Silberschmidt), while the clinical observations of Preti, confirmed by the previous experiences of Rambousek and statistics generally, attribute considerable responsibility to this etiological factor.

Much less certain, and indeed denied by some authorities (Hahn, Silberstein), is the part played by lead in the etiology of certain nervous troubles (headache, irritability, insomnia, tremor, distaste for work) found among printers and attributed by Carozzi not so much to lead as to long hours, accelerated rhythm, strained attention, factors aggravated by night work and the effect of alcohol and tobacco which are abused by some printers. Among 600 printers examined by Carozzi, none was found to be affected with organic or severe functional nervous lesions; but he did find among some of them a diminution in the sensibility of the fingers, slight tremor of the hands only, exaggerated during the evening as a result of fatigue. Fatigue is also the cause of muscular cramp of the hands among compositors and especially linotype operators; among these latter the symptomatology and eio-pathogenesis are identical with those of the cramp experienced by typists. Jacobi has reported also two cases of tetanus; others have described temporary radial paralysis as characteristic and, more rarely, lead encephalopathy, favoured by alcoholic excess. Certain peripheral nervous lesions (neuritis, neuralgia) attributed to the effect of certain working tools, are exceptionally rare. Among 174 such cases reported up to 1901 in medical literature, Baratis has only found two among printers. Hahn has also noticed that typefounders (who are more exposed than printers to the effect of lead) show a figure for nervous diseases as low as that of printers, whilst lead poisoning is less frequent and neurasthenia more frequent.

After lead, account must be taken of antimony, which may set up morbid changes. The first cases of poisoning were described by Schrumpf and Zabel (1910) in three compositors. Other cases have been reported subsequently by Walther, of Chicago, who was able to demonstrate the presence of antimony in the urine.

The results of the enquiries, however, do not lead to any definite conclusion (see article "Antimony").

In addition to poisoning by benzene and also by benzene used by the machine minders, noted as early as 1910 by Carozzi, since when it has become more frequent, there must also be taken into account now the possibility of poisoning by xylol and toluol, reported by Stocke (1929) among makers of blocks for illustration (Tiefdruckverfahren). The oil colours are dissolved in substances generally known under the name of "xylol" which is
used to wash the blocks, but they really consist of benzol at 30 per cent., containing also appreciable quantities of carbon bisulphide. In one machine minder Brocher (1930) reported a fatal case of chronic benzol poisoning, with a clinical picture of atrophic panmyelopathy (aplastic anaemia); in the blood he found 80 per cent. lymphocytosis and 90 per cent. punctate basophilia.

A new occupational risk menacing the workers is mercurial poisoning, reported by Koelsch and due to a recently introduced technical process (see article “Photo-engravers”). In some categories the possibilities of troubles caused by the use of bronze colours has to be taken into consideration; these colours consist of an impalpable dust containing a fairly high percentage of copper and traces of lead (Carozzi). (See also article “Bronze”.)

HYGIENE

Hygienic measures for the printing industry are self-evident from the descriptions already provided. General measures of hygiene are the same as those for all industrial establishments.

On the other hand special measures are required in printing workrooms.

The number of rooms should be in proportion to the importance of the establishment and, even in the case of the smallest printing works, the composing room, especially if linotype machines are used, should be separated from the printing room.

Cubic space and floor space per workman in the different rooms should be adequate; in certain countries legislative measures specify precise figures for each section. There should be ample ventilation, without, however, creating too strong a draught, which in itself is a source of illness or discomfort. Dust should be eliminated, as this is the most important source of injury. So far as cleaning the cases is concerned, good technical apparatus is at present available for removal of the dust by fixed or mobile exhaust apparatus.

The number of benches and uncovered shelves should be restricted as far as possible.

The fittings should be constructed in a uniform manner without cracks and should be covered if possible with washable varnish; similarly, the walls should be varnished at least to a certain height so as to permit of removal of dust by damp methods. Localised ventilation should be applied to the metal pots of the machines.

Good natural and artificial lighting should be provided (see article “Lighting”). According to recommendations that have been made, printing rooms should have the following amounts of light expressed in lux:

<table>
<thead>
<tr>
<th></th>
<th>Eck and Goodenough</th>
<th>Gaster</th>
<th>Home Office (Great Britain): minimum recommended</th>
<th>Lighting code of the Illumination Soc. of U.S.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linotype</td>
<td>50-200</td>
<td>30-80</td>
<td>50</td>
<td>100-200</td>
</tr>
<tr>
<td>Monotype</td>
<td>30-80</td>
<td>60-80</td>
<td>50</td>
<td>100-200</td>
</tr>
<tr>
<td>Hand-composing</td>
<td>50-140</td>
<td>60-80</td>
<td>50</td>
<td>100-200</td>
</tr>
<tr>
<td>Stereotyping</td>
<td>20-100</td>
<td>40-80</td>
<td>30</td>
<td>50-100</td>
</tr>
<tr>
<td>Printing</td>
<td>5-40</td>
<td>--</td>
<td>30</td>
<td>50-100</td>
</tr>
<tr>
<td>Proof-reading</td>
<td>10-80</td>
<td>50-100</td>
<td>30</td>
<td>50-100</td>
</tr>
</tbody>
</table>

For details readers are referred to numerous reports, especially the English ones (L. Gaster, 1923; Goodenough on Gas Lighting, 1912; J. Eck on Electrical Lighting, etc.).

Washing and cloakroom accommodation and water-closets should be installed; there should be a supply of drinking water and water for personal cleanliness, etc. This is very important, in view of contact with lead, antimony, and in some departments with chromates, benzene and other solvents (see also article “Photo-engravers”).

Overall should be provided for the workpeople; eating, drinking and smoking in the workrooms should be prohibited; workers should be obliged to wash before leaving work and before eating; the bad habit of putting type into the mouth should be prohibited and likewise any other method of working favouring the inhalation or swallowing of poisonous dusts.

The prohibition of spitting, especially on the floor, should be enforced.

In rooms where ruling has to be done, the use of sulphur pigments should be prohibited and no poisonous colours used (Stackovsky); precautions should be taken to avoid splashing of ink and dirtying the hands. Gloves should be used for cleaning machines.
and for handling the ink ribbons. The hands should be cleaned with denatured alcohol or other effective solvent.

Thorough and strictly applied selection of workers should be adopted in view of the fact that experts are agreed in attributing a certain percentage of illness to the fact that workers are engaged at too young an age and are generally of feeble constitution.

It is for this reason that certain laws require a medical examination prior to commencement of work and sometimes even a periodical one thereafter. Thus for example, in Italy, the Code of Industrial Hygiene requires special examination of the cardio-vascular system, the state of the blood and condition of the kidneys. Such measures will contribute to the diminution of sickness and mortality rates amongst these workers, as they will serve to bring to light early manifestations of broncho-pulmonary disease of a tubercular character or the early symptoms of lead poisoning.

LEGISLATION

In general, women are excluded from work in casting lead (stereotyping, compositing); sometimes from work at polytype machines. In Norway this only applies to women who are pregnant. In Argentina workers in the printing industry only work six hours a day, the industry being closed during the week-end (Law 11 March 1930).

A draft Code of Regulations for the printing industry was discussed by the International Association for the Legal Protection of Workers at its Conferences of 1908, 1910 and 1912.

Special rules have been enacted: in Germany (31 July 1897, 1 July 1907, 22 December 1908, relative to plant, and work effected in printing establishments; 18 December 1908 on linotype machines; in Saxony an Order of 1910 applies to the cleaning of cases by means of suction apparatus); in Austria (23 August 1911 and 17 July 1912); in Denmark (17 January 1904 and 17 January 1910; an Order of 31 May 1907 deals with photo-typography and lithographic printing; a Decree of 1906 excludes young persons under eighteen years of age from work connected with stereotyping); in Finland (25 May and 7 June 1917); in Great Britain (11 April 1911 on typographic bronzing and lithographic printing); in Greece (11 and 24 February 1914); in the Netherlands (21 August 1918); in Switzerland (Federal Instructions to inspectors have been issued relating to measures for preventing injury to the health of compositors and type casters. February 1898); in Czechoslovakia (26 May 1925 and 25 June 1966); in the U.S.S.R. (19 May 1924), etc.

In the Netherlands notification of cases of inflammation of the joints and subcutaneous cellular tissue in printers is compulsory. Compensation for lead poisoning and its sequela (as in the first column of the formula in Great Britain for industrial diseases) for persons employed in the printing industries is provided by the Convention of 1925 and countries ratifying the same. Lead poisoning comes within the Compensation Act also in France when it affects machine compositors, and in Italy and the U.S.S.R. compensation is provided for progressive myopia among proof readers.

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Pyridine

Pyridine (C₅H₅N) is a colourless liquid, with a specially disagreeable odour; it is relatively volatile at ordinary temperature and boils at 115° C. It is used for denaturing alcohol, purifying synthetic indigo, preparing anthraquinone and, in certain processes, for indanthrene colouring matters, etc.

Amongst the homologues of pyridine should be mentioned the picolines (methylpyridines), the lutidines (dimethylpyridines), collidines, pyridones, etc. Pyridine bases are found in liquid products derived from the pyrogenic destruction of hydrocarbonic and nitrogenous products, in the fumes given off during melting and saponification of fatty acids (with acrolein).

Pyridine is prepared from coal tar subsequent to extraction of phenol, the pyridine oil obtained being treated with sulphuric acid. The sulphate thus formed is extracted by various methods. It can also be got from quinoline or synthetically.

The injuries caused by pyridine occur either in course of its preparation or its use (denaturing of alcohol, etc.) or again in course of the use of products thus denatured (alcohol, lacquers, etc.) and affect polishers, gilders, pencil manufacturers, etc. In the form of fumes, pyridine exercises an irritating action in the respiratory passages — inflammation, coughing — on the mucous membrane — eyes and nose. When ingested it causes various symp-

...
ton's: sialorrhoea, headaches, vertigo, prostration, dyspnoea, trembling, etc. Hamilton mentions that inhalation of pyridine fumes "excites" the workers. It causes dryness of the skin and makes it specially sensitive to the sun's rays, and also eczema — polish-er's eczema particularly among cabinet makers especially. The fact, however, that such workers utilise other irritant substances leaves it open to doubt whether the dermatitis in ques-tion is exclusively due to pyridine. Workers coming in contact with this substance complain, besides, of a particular form of pain in the hands and face when they go out after washing in water.

A peculiar harmful effect of pyridine on the haemoglobin was noted by Zey-nek in 1925.

Injuries due to pyridine are compensated by law in Finland.

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**Pyroligneous Acid**

Pyroligneous acid (see articles “Acetic Acid” and “Timber Industry”) is rectified by distillation to separate it from the tarry substances with which it is mixed.

Buildings in which purification of pyroligneous acid takes place should be remote from dwelling houses, the flooring should be of cement, and the workshops thoroughly ventilated. The processes of distillation, rectification and concentration should be effected in closed apparatus. Large exhaust hoods should be placed above the apparatus enabling the fumes given off to be led into a high chimney. The gaseous and volatile products which do not under go condensation should be burnt. Waste water should be neutralised before being allowed to leave the factory.

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Quinine


Quinine is one of the numerous alkaloids of the quinine or cinchona tree (belonging to the genus Rubiaceae), comprising many species, all indigenous to South America and now acclimatised in other countries (Ceylon, Java, etc.). The quantity of alkaloids varies according to the species, the state of the plant, the climate and the season. Cultivated plants yield much more (especially of quinine) than the wild plants. Furthermore, choice of certain varieties, methods of culture and of industrial treatment enable an excess of one kind of alkaloid or another to be obtained according to preference. Thus the harvesting of bark designated by the term “moussaga” has the effect of producing a considerable increase in the quinine content.

Pure quinine (hydrated quinine C₆H₈N₄·3H₂O) takes the form of fine white crystalline needles with a bitter taste melting at 51° C. Heated to above 100° C. quinine loses its crystallisation water, resumes its solid form and then melts at 172-175° C. Very slightly soluble in water, it is more easily soluble in alcohol, ether, chloroform and still more so in various acids accompanied by formation of the corresponding salts.

The harvesting of the bark is effected by cutting down and stripping the tree (South America) or by barking only (India, Java) and by “moussasure” or covering with moss the parts stripped of bark. The pieces of bark, after being dried in the sun, sorted as to size, ground in crushers or pounded with a mortar, are thereafter finely pulvurised in mills suited to the purpose. The powder is made into a paste with milk of lime, to which a little soda has been added, in vats provided with stirrers, and then subjected to heat treatment in closed apparatus with oils (shale or paraffin, lignoine, benzine, tetra-chlorethane or even ether). These products dissolve and fix the alkaloids given off. When left to settle the solvent becomes separated and can be decanted. The residue is again treated with the solvent in order to exhaust it. The various parts of the solvent are collected and mixed with a solution diluted with sulphuric acid which has the effect of extracting all the acids present in the form of soluble sulphates. The alkaloid is distilled to recover the solvent, which on liberation may be utilised for further extractions.

The sulphate solution is heated, concentrated and left to cool. The sulphate of quinine which separates out in a crystallised and impure state when left to settle is dissolved in water or precipitated by ammonia, then the product is allowed to cool and crystallises in fixing 3 molecules of crystallisation water.

Amongst the other alkaloids present in the mother liquors may be recalled cinchonine, which is the alkaloid of second importance in quinquina, and a mixture of amorphous alkaloids known under the name of quinoidine which can be extracted by appropriate treatment.

Sails of quinine may be obtained in a pulverulent state; manipulation and packing of these in packets or bottles involve a series of operations generally effected in different places by special groups of workers.

The quinquina bark like its alkaloids is used in pharmacy and as an insecticide for moths to protect furs and woollen materials, etc.

Sources of Risk

Amongst workers engaged in removing the quinquina bark in the Java plantations cutaneous troubles analogous to those due to quinine have been noted (Jaquet, Besiner, Brocq, Thibierge). Similar lesions have been reported by Cherallier (1852), Bazin (1862), Leroy des Barres and Courtois-Suffit (1928) amongst workers engaged in boiling the quinquina bark for various pharmaceutical preparations.

It is however chiefly the grinding of bark in the open which causes harm, which may be notably diminished or even eliminated by the use of devices to prevent liberation and diffusion of dust and contact with powdered quinquina.

Boiling or extraction by oils or acids may likewise constitute a source of
risk. According to Blamoutier and Joannon (1922) the proportion of workers affected in this department of the factory amounted to about one-fifth, despite the fact that these operations were effected in closed apparatus.

Drying and manipulation of salts of quinine constitute, according to well-recognised authorities (Chevalier, Bazin, etc.), a source of risk. Certain experts even consider that disease symptoms are particularly occasioned by the preparation of powdered quinine (Dold and P. White), which operation is, however, esteemed by others to be harmless (Blamoutier and Joannon). However that may be, cases of affections due to quinine are known to have occurred amongst hairdressers affected with papular eczema of the hands and especially of the fingers following on the application of lotions with a quinine basis (Kober), amongst pharmaceutical chemists and druggists, etc. Cazeneuve (1930) noticed amongst workers tending machines for the manufacture of compressed tablets of salts of quinine several cases of skin troubles, which however healed very readily on application of soothing ointments. Traces of quinine powder liberated by these machines were partially absorbed by the buccal passage (as revealed by the bitter taste experienced by the women workers), and the effect of these contributed to increase that exercised by the direct action on the skin of the hands and face.

Another source of risk is to be sought in the various products (solvents and acids) handled in course of preparation of the quinine. Several cases of poisoning have been caused by tetrachloroethylene.

TOXIC ACTION

Quinine is a poison of the protoplasm; in large doses it paralyses and kills the cells (Robert). Quinine is, however, of no interest from the aspect of industrial medicine except as regards its local irritant action. Cutaneous troubles caused by quinine used as a medicament are very well known, and forms of occupational dermatitis due to quinine dermatitis do not essentially differ from these as regards their etiology; they represent a manifestation of special susceptibility of the individual affected like most other form of dermatitis.

The means of entry into the system is said to be principally internal absorption (digestive and respiratory passages). It is a fact that visitors to a quinine factory become aware, after a certain time, of a bitter taste due to the quinine dust inhaled and swallowed and which the workers no longer experience. Nevertheless, it cannot be denied that quinine may also traverse the epidermis when favoured by erosions; in this case likewise it exerts its effect after having been absorbed by the system (Blamoutier and Joannon).

The other factors capable of diminishing the resistance of the body (alcoholism, tuberculosis, etc.) seem to be without special importance in this instance, nor can personal cleanliness be said to diminish liability to troubles provoked by quinine.

The dose of the toxic product would appear to play a distinct role in the genesis of accidents provoked by quinine. So far no light has been thrown on the exact nature of the susceptibility for quinine, susceptibility the existence of which must, however, be recognised.

It has been observed that certain newly engaged workers who have not suffered any effects after an average lapse of time of fifteen days from commencing work would appear to be definitely immune. There is therefore on employment a species of trial which decides the fate of the worker, and this early occurrence of reaction attenuates to some extent the trying effects of quinine eczema. Nevertheless, in very rare cases, chiefly after a severe illness, workers who have never had skin trouble have suffered from a slight eruption on return to the factory. Their natural immunity had weakened without, however, disappearing entirely, for the eruption was not repeated.

On the other hand, the majority of workers, who seem to develop a certain degree of tolerance, after having suffered from effects are well aware of the persistence of their susceptibility; when suffering from quinine eczema they do not return to the factory to draw their pay but send their wives. Where the wife of a worker who has had to leave his employment on account of intolerance of the product is also employed in the preparation of quinine, she is obliged to give up her work altogether in order to avoid prolonging her husband's condition or causing him relapses, since the substances impregnating her clothing suffice to provoke the symptoms. This latent susceptibility persists even after quitting the factory and may be evoked by the slightest cause (use of apparatus or instruments which have been in contact with quinine, passing near a quinine factory, taking quinine as a medicinal remedy: Lewin). Cutaneous lesions noted amongst wives and children of workers who
bring home traces of the alkaloid in their clothing are to be ascribed to phenomena of individual susceptibility. It is highly probable that in the case of specially sensitive workers anaphylactic phenomena come into play. Workers suffering from quinine eruptions rapidly (from a few hours to fifteen days' time) progress towards either of two states: either one of apparent intolerance, during which the system becomes progressively modified by "preparatory doses" of the quinine; or the other of intolerance, during which the system reacts to doses causing outbreak of symptoms, even with slight amounts of the substance. Simply remaining for some little time in the factory without being at work there at times suffices to cause an outbreak of dermatitis. Blamoutier and Joannon refer to the case of a mechanic who spent a half-day in a factory to effect repairs and who suffered next day from the typical eruption.

**STATISTICS**

Statistical data are scarce, but in the reports of factory inspectors in the various countries cases of dermatitis caused by handling quinine have been reported. (See especially the reports of the English and German factory inspectors and those of the Swiss National Accident Insurance Fund.)

**PATHOLOGY**

Injuries consist essentially in forms of dermatitis situated on the extremities and on the scrotum. Skin trouble affecting this part of the body was reported as far back as 1852 by Chevalier and is, according to Blamoutier and Joannon, of early appearance, though at times delayed for a long time (after four weeks). At the outset the trouble usually consists in transient erythema accompanied by a burning sensation and pruritis (even without eruption situated in the folds of the skin (elbows, armpits, groin) as well as on the face, which becomes oedematous and slightly reddened. It is chiefly, moreover, round the eyes that the foremen look for symptoms in newly engaged workers in order to remove immediately susceptible subjects. Manifestation of large quantities of quinine, particularly for its preparation in powdered form, causes cutaneous affections, particularly on the eyelids (Lehmann, Dold).

There follows a period characterised by a sensation of burning, situated on the face, neck, bends of the joints, on the genital organs and the inner surface of the thighs. The eyelids are red and inflamed; the eyes swollen and watering and the patient has difficulty in opening them and on the uniformly red surface of skin are noted, in groups or disseminated, vesicles of varying size, often acuminate, in general small and containing a purulent or citrine liquid. On being opened they emit a thready, sticky, viscous and serous liquid forming yellowish crusts. According to Blamoutier and Joannon, the hands, forearms and the whole of the trunk are in general scarcely affected — which statement is in contrast with many at times the clinical description: "most usually on the hands and forearms" (Leroy des Barres, Courtois-Suffit, Chevalier); generally on the backs of the forearms, on the lateral sides of the fingers and at times on their palmar surface (Glaser). The most usual form of these affections is that known as "quinine itch" (Chininkrätze, gale de la quinine). Those employed on peeling and stripping the quinquina bark may suffer from a more simple form, characterised by very small vesicles and presenting the appearance of orange skin (Thibierge, quoted by Prosser White, and Ullmann).

According to Lewin, the clinical forms which may be met with are as follows: (a) isolated erythema located on the trunk, the face, the limbs, or simultaneously on various parts of the body, which may at times be generalised and sometimes resemble measles. The forms of exanthema described by Glaser as affecting the wives and children of workers come within this category. It is mostly a case of mono- or polymorphic lesions generally with very rapid development which are of slight degree and disappear equally rapidly, but which may in other cases last for several weeks and which are followed in most cases by desquamation. In some rare cases there is (a) pigmentation of the skin; (b) eruption of a scarlatina form type (the most frequent form) accompanied by general disorders (oppression, excitement, delirium, etc.); in serious cases there may occur erysipeloid dermatitis; (c) gangrenous dermatitis: very rare, referred to by Blamoutier and Joannon; (d) multiform exuding erythema: rare; (e) purpuritic or confluent urticaria; (f) bulbous exanthema resembling pemphagus; (g) petechial form.

Lehmann also reports an obstinate cough as an effect and Loewy amaurosis due to constriction of the blood vessels.
QUININE

HYGIENE

Industrial processes, particularly the grinding of bark, should as far as possible be effectuated in closed apparatus. Hand work should wherever possible be replaced by automatic work, especially in the transport and manipulation of quinquina. Extraction of the alkaloids by solvents should be done in closed apparatus. There should be adequately disposed local-exhaust ventilation for capturing and recovering the dusts and fumes from the solvents, the commercial value of which is obvious. Facilities for personal hygiene should be provided (baths, wash basins, working clothes, etc.). The bad habit practised by workmen engaged in quinine extraction of cleaning their hands after work with a very diluted solution of sulphuric acid to remove more readily the shale oil should be prohibited (Blamoutier and Joannon).

Where skin trouble is persistent, the workers in question should be removed from the operations exposing them to risks.

Certain authorities recommend the use of biological sensibility reaction tests either on entering the trade or during the first few days in the factory to determine susceptibility and permit of removing those affected prior to the occurrence of dermatitis. For this purpose slight scratches are made and dusted with quinquina or painted with 1/10, 1/100 or 1/1000 solutions. Fifteen minutes later susceptible subjects present in situ oedema and redness not noted in the case of individuals who can stand quinine in internal doses (Boener).

It might likewise be possible to attempt to desensitise subjects affected (Blamoutier and Joannon).

LEGISLATION

Legislative enactments require notification of skin diseases due to quinine (eczema and dermatitis) in the Netherlands, and compensation of injuries due to quinine in Switzerland and in those countries in which skin diseases (due to liquids, dusts, etc.) have been inscribed in the schedule of occupational diseases entitling the worker to compensation (see these articles).

BIBLIOGRAPHY


Radium and Radioactive Substances


PROPERTIES

Radioactive ores are of very varying kinds; examples are: carriotite, a vanadate of uranium and of potassium, found in Colorado; autunite, an anhydrous phosphate of uranium and calcium, found in Portugal; betafite, a niobotitanate of uranium, from Madagascar; pitch-blende, an oxide of uranium; chalcolite or tobernite, a phospho-uranate of copper; curite, a uranate of lead, and kasolite, a silico-uranate of lead, from Katanga.

These ores appear in the strata in varying proportions, and with extremely variable strengths of oxide. Radium is found in all the ores of uranium from which it originates during the process of disintegration in the proportion of about 3,400,000 parts of uranium to 1 part of radium. Whilst at Katanga, for example, 1 gramme of radium is obtained from 10 to 20 tons of ore, elsewhere, and especially in America, 1 gramme is only yielded by 200 to 500 tons of ore.

Radium, of which the molecular weight is 226, has been prepared in the metallic state by Mme. Curie and Debierne. But it is generally used in the form of its compounds, as the bromide, chloride, sulphate, or carbonate. The radiations emitted by preparations with a radium base are not homogeneous for they contain alpha, beta, and gamma rays.

INDUSTRIAL OPERATIONS

The manufacture of radium is still carried on to-day by the methods employed by Mme. Curie and Debierne. It includes three stages arranged systematically: grinding the ore; treatment with acids to eliminate such inert materials as uranium, iron, copper, lead, aluminium, and silica; treatment for separating the radium from lead and barium, which hold it in the form of insoluble sulphates, and for eliminating sulphuric acid.

Radium, during these processes, exists in an insoluble form, mixed with silica, which is removed at the commencement of the treatment by the action of hydrochloric acid.

Each of these operations necessitates filtrations and washings. Thus radium is concentrated from 1 part by weight for 10 to 20 million parts by weight of inert matter down to 1 part for 125,000 of inert matter, which is chiefly barium.

A second stage follows, in the course of which the sulphates obtained are transformed into carbonates, which are in their turn transformed into chlorides. In the impure solution of chloride of barium and radium so obtained, the radium is still found in the proportion of 1 part per 125,000 of barium.

The third phase of the manufacture consists in purification and concentration; it is carried out by fractional crystallisation, first in aqueous solution, then in hydrochloric solution, and finally in hydrobromic solution.

The enriched crystals are dissolved in boiling distilled water up to saturation point, and, after having been evaporated, are allowed to crystallise; impoverished solutions are similarly treated. In this way crystals are obtained of which the radium content always goes on increasing, and solutions of which the content always goes on diminishing. Crystals with a radium content of 0.05 per cent. are set aside and sent to the laboratory, where the work of crystallisation is only carried on when 2-3 grm. of radium have been amassed. Each series of operations involves, besides crystallisation, purification by sulphuretted hydrogen in order to remove the last traces of lead, and the transformation of chlorides into bromides, a process which allows a more advantageous coefficient of concentration to the crystallisation. The strength in radium is thus brought from 0.05 to 97-98 per cent., which is
the usual strength of the product when ready for sale.

This long procedure, which lasts several months and requires hundreds of operations, gives a small white mass, rather like table salt; it is very luminous in the dark; its radioactive power, which is not influenced by any chemical process, is proportional to the fraction of the radium element present in the salt. No effort is made to procure radium in the metallic state. The bromide of radium is obtained; it is dried, put into glass tubes, sealed at the blow-pipe, and estimated for radioactivity at the laboratory attached to the factory.

There is no need to enter into details concerning the technique for determining the quantity of radium found. It is enough to say that use is made of a method of measurement based on the electric conductivity or ionisation acquired by air under the action of radioactive substances. The speed of discharge of an insulated conductor, placed in the presence of a quantity of radium to be estimated, is measured by comparing the rate of discharge produced under the same conditions by a known standard quantity of radium. All the uses for which radium is required, as applied to therapeutic purposes, have to be borne in mind. The apparatus for containing radium consists of small cells, needles, and tubes made of platinum treated with iridium, very small in size and very delicate in construction.

The manufacture is, in all its various stages, encompassed by a series of preventive measures designed to protect the personnel exposed to the radium as much as possible. Not only are tables covered with lead, lead shields, and india-rubber gloves used, but regularly every day the emanations remaining in the solutions are pumped out; the operations of refilling are carried out with all possible rapidity, and the personnel is periodically subjected to medical supervision, which includes monthly examinations and analyses of the blood.

The chemical properties of mesothorium are almost the same as those of radium. It is extracted from monazites by a process which is analogous to that used for the extraction of radium. Mesothorium is very often mixed with radium, and it is naturally difficult to distinguish between the action of the two bodies.

**Sources of Risk**

The first observations on cutaneous lesions caused by radioactive bodies date from 1900, when Giesel and Walkhoff made the first experimental researches with radioactive substances. On the basis of these results, it has been possible to find an explanation of the cause of the cutaneous lesions found in 1901 on Becquerel himself, following the handling of a tube containing radium, which he had carried in his pocket for several hours.

Dobudutz has collected at least six cases of dermatitis occurring among persons employed in the preparation of products with a radium basis. The lesions were generally situated at the ends of the fingers, and especially on the thumb, the index and middle finger; in two cases a slight atrophy was found also. There is frequently degeneration of the nails, which fall off, this being caused by the action of the beta rays, and perhaps by secondary, very penetrating rays.

Mesernitzky has also reported cases of cutaneous lesions, localised on the fingers of three persons employed in the laboratory of Mme. Curie, due to radium emanations of from 50 to 130 milli-Curie.

Gudzenz and Halberstaedter in 1914, and Th. Ordway in 1916, published a series of cases of occupational dermatitis and of lesions of the nails due to radioactive bodies, reported up to the years mentioned.

Friedlaender reports a case of chronic dermatitis caused by mesothorium, observed in a woman working in an incandescent mantle factory. The lesion, which was localised in the upper limbs, appeared after she had been handling a 1 per cent. aqueous solution of nitrate of cerium and thorium for two years. The necrosis of the jaw observed in America among women workers who handle luminescent paints is also attributed to mesothorium (see further on).

The occurrence of injuries caused by radioactive preparations on the skin, in the case of doctors and others who use them for therapeutic purposes, is extremely rare, and is even denied by some experts. But it should be noted that whilst the doctors only use the most minute quantities of radium, those who prepare the substances and the technical experts who study the physical and chemical properties of radium handle very much larger amounts.

Cases of cutaneous lesions localised on the eyelids have also been noted. Attention has been drawn by Joist to the danger of explosion from bromide of radium when it comes in contact with water; two cases of severe irritation of the eyes have been reported.

**Pathology**

The various elements of the radium series emit three types of rays: alpha, beta and gamma, the last of which are chiefly used in medicine. The alpha rays are the least penetrating, and only possess a speed equal to that of light. The alpha and beta rays can be separated from the gamma rays.
by making the mixture of the three rays pass through screens of adequate thickness. Alpha rays are positive electrons; they cannot penetrate metals. Beta rays are negative electrons; they can penetrate thin screens of aluminium. Gamma rays, which have a speed equal to that of light, are, from the electrical point of view, neutral, but they possess a great power for penetrating opaque bodies, so that they can pass through a lump of lead 19 cm. thick.

Daily exposure to rays of radioactive substances is a source of danger not only to those who handle them — doctors, hospital attendants, the personnel of research laboratories and therapeutic clinics — but also to persons employed in the industry who prepare or manipulate radioactive bodies and to workers engaged in the extraction of radioactive ores (see also article "Tumours of Occupational Origin").

Today this danger is only slight for those composing the first group, who are sufficiently protected and supervised, so as to prevent any local injury, such as radium dermatitis or sterilisation, or such general damage as anaemia or leucopenia. However, serious or even fatal cases are known to occur among persons of this group. Thus, for example, Siebenrock in 1911 recorded a fatal case of leucæmia (without any other indication) in a chemist who handled radium, and Schwartz a case of leucæmia in a chemist engaged in the preparation of radium.

A case of aplastic anaemia has been reported in the case of a woman who had worked for several years in a radium institute, and, neglecting every precaution, while carrying boxes of radium, placed them on her chest for fear of losing them. This woman, after experiencing a transitory dermatitis of the hands, showed signs of becoming anaemic, with red cells below a million, leucopenia, relative mononucleosis, and a scarcity of thrombocytes; the development was swift and fatal, the total period from the beginning being eight months. (Case studied by Brulé and Boulin, 1922.)

A radiologist, reported by Dominici, succumbed to aplastic pernicious anaemia due to radium. He was in the habit of carrying pieces of radium in his pockets, and showed pigmentation of the skin on his body at this level.

Following three fatal cases of anaemia with leucopenia among the personnel of the Radium Institute of London, Mottram undertook in 1922 an enquiry, which lasted a year, into the conditions of the personnel exposed to radia-

izations. He came to the conclusion that these workers are subject to blood changes, greater in proportion to the length of time they are exposed to radiations. He examined 40 adults, 20 of whom were specially employed on radium and 18 on X-rays. He found the number of lymphocytes and of polymorphonuclear neutrophile leucocytes abnormally low, especially among the radium specialists. The gamma rays of radium act on the bone marrow, whilst the less penetrating X-rays exert their action more particularly on the lymphocytes and the lymphoid tissues which are not protected by the bones.

During one year, 1922-1923, Williams examined 13 persons employed in the United States in measuring the radio-activity of radium preparations.

Two persons, one of whom was in employment actually at the time of the enquiry, while the other had been previously employed, showed symptoms indicative of the effects of radiations on the skin of the hands and fingers, with pain, anaesthesia, burns and destruction of the skin, as well as of the parts underlying the seat of the lesion.

The general symptoms were headache, malaise, weakness, fatigue, sleeplessness, and vertigo.

Blood changes have also been reported. A tendency appears for the white polymorphonuclear neutrophile cells to fall below normal, with a diminution in the number of small lymphocytes, an increase above normal of the large lymphocytes, and a tendency to decrease in the number of white cells in general, as well as of red cells.

Amongst workmen exposed to radiations, a diminution occurs in the arterial pressure, which falls below the normal.

There is quite a series of occupational pernicious anaemias, due to X-rays, to radium and thorium which cause the aplastic type and result in progressive destruction of the haemopoietic centres after prolonged exposure to the harmful agents. Such is the case in two observations of Emile Weil and Lacassagne (1925) on two engineers manipulating thorium, both of whom died, one from myelogenous leucæmia and the other from aplastic anaemia. In 1924 Amundsen recorded leucopenia in 15 persons in contact with radioactive substances.

It must be admitted that, in addition to blood changes, exposure to radiations also causes leucæmia. This form of leucæmia may perhaps be characterised by the concomitant action
of the radiations on the genital organs, for atrophy of the testicles or ovaries is found both clinically and anatomically.

It is a curious fact that in the case of robust men, without any defects and approximately of the same age, the same radiations of thorium may cause in one aplastic anaemia and in another leucæmia. It is difficult at the present time to explain this phenomenon; can it be due to the nature of the constitution? (Case of Weil and Lacassagne.)

With the cases observed by Lacassagne and Emile Weil, these give, up to the year 1925, 8 cases of leucaemia by radioactive bodies, and exactly 5 cases amongst radiologists, 1 in a person who handled radium, 1 in a person who handled thorium, and 1 following the therapeutic use of these bodies.

E. Rud examined, in 1924, the blood of 18 persons, of whom 6 were doctors and 6 hospital attendants employed in radium and X-rays institutes, without finding any appreciable blood changes.

Certain other experimental researches into the action of radium on the blood lead to the conclusion that prolonged exposure lowers the number of blood platelets. This change is followed by a return to the normal; then by an elevation above normal; and finally by a second return to the normal figure. (Mottram.)

In addition to these various occupational illnesses caused by the handling of radioactive bodies among persons who work in laboratories with therapeutic preparations of radium without proper protection and supervision, quite a number of very serious or fatal illnesses must be mentioned occurring among women workers who handle luminous paint with a basis of sulphide of zinc and which is the consequence of an attack on the haemopoietic organs and pernicious anaemia.

The person affected complains of gingivitis, generally complicated by alveolar-dental pyorrhoea; the teeth become painful and loose, and may fall out spontaneously. Removal of teeth has the same disappointing result as in the case of phosphorous necrosis. The bone necrosis begins with destruction of the alveolar border; its course is slow and progressive, and the lesion may lead to the spontaneous fracture of the lower jaw. When it attacks the upper jaw it is less. It may lead to perforation of the bony partition, and even break into the sinus. The pain is terrible. Although one may come across slight forms, which tend to get well after the removal of some teeth, and the resection of part of the jaw, there are others which are complicated by suppurative parotitis and progressive cachexia, passing on to a fatal termination. But death in these cases is the consequence of an attack on the haemopoietic organs and pernicious anaemia.

The enquiry held by American experts established that this serious lesion originated from the bad habit, when at work, of pointing the brush between the lips without washing it in the small phial of water provided for the use of the women workers. Particles of the radioactive mixture are in this way introduced into the buccal cavity, and deposited in the alveolar-dental spaces. It must be acknowledged,
However, that a hundred pointings of the
brush would not at the most introduce more than 25-50 millimicro-
grammes of radioactive element (one milligram a month), most of which would be
drawn into the digestive passages with the saliva. It is indeed hard to
believe that this infinitesimal amount of radio-active substance can cause
lesions as serious as those described
(Hoffmann). But other experts, such as
Martland, have estimated that these
women workers can paint 200 to 300
dials per day, and that in the course of
this work they carry their brush to their lips from one to forty times for
each watch. This procedure would represent the ingestion of 3 to 43 micro-
grammes of radioactive substance per
day: a quantity much higher than that
mentioned by Hoffmann. On the other
hand, experts have shown the presence of the substance in question in the
jaws by measuring the radioactivity of secondaries removed surgically. Mart-
land has detected radioactivity in the air expired, which he characterises as
one of the most important symptoms.
This radioactivity has been found in the
tissues after death, and in one case even five years after death (St. George,
Cettler, Müller).
Bridge, of the English Factory Med-
cial Inspection Department, made an
enquiry, in 1925, into the industry in
question, which, however, did not em-
ploy more than ten women. The paint
was made of a solution of sulphide of
zinc, containing about 0.0375 millimicro-
grammes of sulphide. He did not find
any ill-effects among these women, who
had worked for some years; but blood
examinations, made by A. B. Rosher,
showed, in the case of three women out
of seven, lymphocytosis, polycythaemia
and deposition in diploph-leuco-
cytes. No changes in the nails or skin of
the hands were found.
Flinn, of New York, in December 1926
again took up the study of this ques-
tion. From analysis of the facts, he
found himself unable to accept the
opinion that any occupational risk existed in the work of painting with
luminous solutions.
In 1926, Reitter and Martland re-
corded the death of a chemist in a
dial-painting factory, and in the same
year Martland found in the bones of the
jaws of one person approximately 150 micro-
grammes of radio-active substance, and the other were
mesothorium and its derivatives.
In 1927, two other cases were re-
corded, one being fatal, of necrosis and
anaemia; in 1928, another death, eight
years after the person had ceased work.
In November of the same year, the
death occurred from aplastic anaemia
of the chemist Sokowsky, the inventor
of the painting formula used by the
New Jersey factory.
In 1929, the United States Bureau of
Labour Statistics carried out an enquiry
covering 31 establishments and 253
workers exposed directly to radio-
active substances. The enquiry re-
vealed 23 deaths and 19 cases of
sickness attributable to radioactive sub-
stances, of which 15 deaths and 18
cases of sickness were due to the paint
in question. The report published
summarises the 42 cases, certain of
which had already been recorded by
other authorities.
In the same year, the Bureau of
Aeronautics of the United States Navy
enacted precautionary measures for its
personnel, and Martland published a
recapitulatory study in which he points
to the presence of signs of osteitis con-
fined to those bones subjected to
traumatism or to exterior pressure, or
supporting weights (scaphoid, spinal
vertebrae, head, femur, etc.), which
produce chronic lesions with pain and
restriction of movement. In these
cases there is in general no anaemia
or necrosis, due perhaps to the fact
that the mesothorium has had time to
resolve into its inert substance.
In 1931, Martland published another
study in which he reported 15 cases of
osteogenetic sarcoma among the 18
deaths (27 per cent.) which had occurred
between 1922 and 1931 among the
women workers of the New Jersey
factory and one case of sarcoma in a
deceased worker of a New York and
Connecticut factory. In addition he
reported one case of obvious and two
cases of probable signs of sarcoma in
three women workers of New Jersey
who were then still alive. In this
instance Martland remarked that all
the injuries met with were to be
attributed to accumulation in the bones
of ingested radioactive substances; the
internal bombardment of the system by
alpha radiations emanating from those
deposits set up not only sanguinary
lesions due to attack on the haeu-
opoietic organs, especially of the bone
marrow, but also injuries of the
nature of osteitis of which necrosis of
the jaw was none other than a particu-
lar form facilitated by the addition
of local microbic infection. He under-
lined the fact that the anaemia referred
to and due to exposure to ex-
ternal radiations (gamma) were of the
aplastic order. He also noted that the
formation of osteogenetic sarcomas
was but a consequence of the process of chronic inflammation of the bones met with in other diseases showing similar processes (Paget’s deforming osteitis, Recklinghausen’s fibrous cystitic osteitis).

According to an enquiry undertaken by the International Labour Office, the absence of radium necrosis in the Swiss, French, German, Australian, English, or Belgian watch factories, where as a rule, the painting is done by the use of a stylet and sucking is unknown lends support to the view that poisoning may arise through use of the brush.

Regaud, who has studied radium bone-necrosis of the jaws ascribed to certain defective radiations either from radium or X-rays, considers that it arises in these cases from soft gamma rays, primary beta, and above all secondary beta rays.

Continued action of alpha rays on the tissues, which completely absorb them, has been thoroughly investigated by means of polonium, the last radioactive body of the radium series.

Lacassagne and Lattès have shown that subcutaneous injection of a solution of polonium, which emits a pure alpha ray, can cause a local radio-dermatitis. If applied to the skin, this solution causes burns, particularly if it succeeds in reaching as far as the deep layer of the epidermis. Further, these experts have emphasised the fact that the quantity of polonium necessary to kill a rabbit by injection is about one thousand millionth part of a grammé.

Therefore it is not surprising that radium, mesothorium and radioradium, which are bodies which give off more intense emissions, have penetrated in the insoluble state into the alveolar dental region, and, after having accumulated there over years, especially under the influence of the bombardment of alpha rays, can lead to necrotic destruction of ligamentous tissue, then of periosteum, and lastly of the bone itself. The action of associated superimposed infections, which play an important part, cannot be overlooked.

Martland, Conlon, and Knef, when studying the general illnesses resulting from absorption by the digestive organs of radioactive bodies, in the course of an autopsy on a patient who had died of pernicious anaemia two years after having ceased to handle these substances, found that radioactivity reacts particularly on the organs of the reticulo-endothelial system.

In Europe there have been several contributions on this subject: that of Jaulin (1927), concerning 17 fatal cases in persons handling radium or X-rays; of Heim, Balsac, Agasse-Lafont and Feil (1930) who studied the personnel of a factory for mesothorium preparations; of Kupritz (1928); of De Laet (1928); of Schlundt, McGavock and Brown (1931) who carried out an enquiry among workers refining radioactive substances; of Woldrich (1931), etc.

By his researches on polonium Lacassagne arrived at conclusions similar to those of Martland given above, thus confirming the demonstration given by Dominici and Faure Beaulieu, as well as by Dominici, Petit and Jaboin, viz. that radioactive bodies persist for a long time in the system. This fact explains the serious lesions of the haemopoietic organs which may appear years after the introduction into the body of the radio-element, and advance to fatal pernicious anaemia.

**Prophylaxis**

Williams recommends the following prophylactic measures.

Examinations of the blood and arterial pressure, carried out at regular intervals, amongst persons employed in the radium department.

Complete medical examination of all employed, carried out at regular intervals.

Medical examination before engagement, including examination of the blood.

When radium is being manipulated, so far as is possible, all protective apparatus must be used — screens, carrying boxes lined with lead, pincers for handling, etc. Adequate ventilation must be provided in the rooms where the handling of radium is carried out.

The personnel must be instructed as to the necessity of reducing to a minimum such absolutely necessary exposure for which no protection from radiations can be afforded, and of not remaining longer than is necessary in the vicinity of radium.

During packing and unpacking of radium, at the receipt or despatch of goods, at the preparation, assembling and placing of parcels in position, and also packing paper and other equipment, all work should be done as rapidly as possible, so as to shorten as far as possible the time of unavoidable exposure to the radiations.
The periods of work of those exposed should be limited to five days a week, so that a period of two days intervenes between two periods of work; these days must not be counted as annual leave, or sick absenteeism.

A grant of thirty days' leave each year, should be made, to be taken, as far as circumstances allow, in two periods of two weeks each every six months.

The two days off work each week, as well as the annual holidays, should be spent in the open air.

A small automatic apparatus recently designed by Poole in 1926 makes it possible to eliminate the use of the hands when manipulating capillary tubes containing the emanation which is divided into fractions, after each operation, by dividing up the tube into small tubes, 1.5 cm. long, by means of a blowpipe.

In this way the extraction and purification of the emanation from radium, involving hitherto dangerous exposure for the manipulators, are rendered almost harmless.

A British committee set up in 1921 issued a code of protective measures, amended in 1925 and 1927, which served as a basis to the International Congress of Radiology (1928) in formulating its recommendations. These were amended by the International Committee on Rontgen rays and Radium, Paris, 1931. (See also the report on this subject of the Health Organisation of the League of Nations, 1931.)

**Legislation**

Compensation is granted for injuries due to radioactive substances in Austria, Belgium, Czechoslovakia, Danzig, Finland, France, Germany, Great Britain, Mexico, New Jersey, New York, Ohio, Poland, Sweden, Switzerland and the U.S.S.R.

**Bibliography**


See also Monthly Labour Review, June 1929, Washington.

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**Rags**


This article deals first with rag-picking, and then with the operations of sorting and shredding of rags or shoddy.

Rag-picking consists of going through household refuse and picking out all articles which have any commercial value. Some rag-pickers go round in the early hours of the morning and collect rags and other refuse from the dustbins which have been placed in the street for the collection of refuse. Others, however, call at houses and buy unwanted objects of all kinds. As this is not a regular occupation, the latter class of rag-picker is generally at the same time a dealer in rabbit skins, a sweep, or a pedlar. The rags are taken to a rag-picker's home or to a depot used by several rag-pickers, where they are sorted. The operation of sorting consists in dividing each object according to the commercial value of the various materials of which it is composed, so that each kind of material can be classified separately. The principal materials distinguished are rags (wool, cotton, silk, linen, etc.), bones, scraps of metal, etc. The rags are then sold to rag dealers who act as middlemen and resell the goods to wholesale dealers. The rag dealers again sort the rags and classify them carefully before selling them to the wholesale dealers.

Besides rag-pickers, who collect their rags from dust bins, the contents of which they scatter on the pavement in order to facilitate their search, there are others who pick out rags from dustcarts in the course of their journey from private houses to refuse dumps. The latter activity is, however, in course of disappearance as the transport of refuse is at present increasingly effected by motor lorries furnished with hermetically sealed covers, which prevent rag-picking during transit.

Rag-picking is also engaged in in factories, where rag-pickers are sometimes allowed to come and remove their booty.
Rag-sorting is an essentially feminine industry. According to statistics prepared by Gilbert (Belgium), 5.4 women to 1 man are met with in this industry. The employment of young persons in the trade is very rare.

The rags arrive at the factory in bales. The bales are opened and the rags are generally placed in thrashing machines, such as the Voith machine. This operation, of course, liberates a considerable quantity of dust, the amount of which varies with the quality and cleanliness of the goods. The rags are then placed on a revolving cloth moving intermittently, which takes them over two small cylinders into closed vessels containing spikes. The heavier waste matter falls and the light dust is drawn by a ventilator into a dust-collector. The latter takes them over two small cylinders into closed vessels containing spikes. The dust which is collected is used for making cardboard or for the manufacture of fertilisers.

The work of sorting consists in tearing up the rags, classifying them in grades according to their material (linen, cotton, wool, etc.), colour, or thickness, and removing all buttons, buckles, and hooks, if they are not made of animal or vegetable fibre. The work is carried on simultaneously with the operation of shredding. The latter operation consists in dividing into strips cotton or linen rags which subsequently go through the cutting and willowing machines, and are then boiled.

The work is done by women, each of whom is given, in the morning, a sufficient amount for the day's or half-day's work. In many cases, rags are sorted in the large rag depots, but the operation is also frequently carried out in connection with shredding in a branch of the paper factory which purchases its rags direct and not through a wholesale dealer.

Rag-shredding rooms are well known to be unhealthy in many respects. The amount of dust liberated is enormous. The atmosphere in rag-shredding rooms is full of thick, clinging, and evil-smelling dust, which settles thickly on the walls, the floors, the furniture, and the workers' clothes. At all times of the year, but particularly in summer, dust settles on the hands and faces of the sorters, and combines with their perspiration to form a sort of paste. Clouds of dust rise into the air, even when rags are simply sorted, but still more dust is caused by the work of shredding or tearing rags, removing buttons, etc. In some workrooms the dust is so thick that the workers cannot breathe unless they tie a cloth or sponge in front of their mouths and noses.

Sviatolowsky has estimated the quantity of dust in rags to amount to from 40 to 70 per cent. The morbidity and mortality statistics for infectious diseases are above the average in those districts in which rag depots and paper factories are situated.

In 1925, Semenow analysed eighteen samples of dust and rags taken from the sorting department of several paper factories. He found, in certain samples, tuberculosis bacilli, mould (fungus: Aspergillus fumigatus), actinomices, particles of organic and inorganic dust, the former chiefly consisting of quartzic sand.
The amount of dust produced varies very considerably according to the nature of the rags. Old clothes produce an immense amount of dust, while new scraps from the dressmaking and clothing industry cause very much less. There is also a considerable difference in the nature of the dust. Rags of the kind mentioned are not liable to cause entrance upon the skin, as may happen with the dust from linen rags for paper factories and new woollen waste for the manufacture of shoddy. Rags are obtained from the most varied sources and may have been used for a large number of purposes. The dust which arises from them may contain mineral elements such as sand and glass, vegetable fibre (cotton, flax, wood, etc.), animal fibre (wool, hair, etc.), and living bodies, such as bacteria and mildew, which may cause putrefaction or more rarely disease (smallpox, tuberculosis, typhoid fever, diphtheria, erysipelas, and occasionally plague, cholera, etc.) or parasitic diseases.

A third feature is the quality of the dust. It is well known that hard particles of dust with sharp edges which easily cause injury act more rapidly and are more injurious than soft absorbent particles of dust. Dust from rags is generally considered less injurious than other kinds in this respect, as it consists for the most part of light absorbent particles rather than mineral particles.

Of these three features — the infectious nature of the dust, its quality (hardness, etc.), and its quantity — the one which gives rise to the principal risk in the rag-sorting and shredding trade is beyond doubt the last. The possibility of contracting infectious disease is far less important.

It would appear from the study of statistics that, apart from anthrax and erysipelas, infectious diseases contracted are more or less rare, since the infective agents lose their virulence by desiccation when the bales of rags are stored for a long time without being opened.

Statistics

Austria. — In 1879 the doctors of Lower Austria observed an acute respiratory disease of unknown nature which affected women engaged in sorting white rags but not those who sorted coloured rags. To this disease they applied the name Hadernkrankheit (rag-sorters' disease). Fourteen deaths occurred in twelve months in a single factory at Glognitz, but no bacteriological examination was made.

In 1887 Schultz, Krahnhals, Hergraven, and Hadecki made a report on an epidemic among women engaged in rag-sorting in an Austrian paper factory which caused seven deaths. Research showed that the disease was apparently an extremely serious one due to some germ closely resembling that responsible for malignant oedema. Other cases reported by Grube recalled the well-known features of the Bradford wool sorters' disease. There can be no doubt that the cases in question were in reality cases of internal anthrax.

Belgium. — In reply to enquiries made by the International Labour Office, the Belgian Factory Medical Inspection Department states that from its point of view the work of rag-sorting is not of special importance. It may, however, be worth while to give an account of some information collected by Dr. Gilbert in 1892.

Dr. Gilbert was not investigating the rag trade as such. His purpose was to enquire into the effect of conditions in the flax industry which is not considered as unhealthy in Belgium. For purposes of comparison he required another trade where similar conditions prevailed, both in the industry and in workers' homes. Such similar conditions he found in the rag trade. The rag workers lived under home conditions identical with those of the flax workers, and workers in the two trades were in many cases members of the same families. Further, rag-sorting is in a large number of cases carried on in the same towns in which the flax industry flourishes. The trade conditions are also very largely similar.

For these purposes, therefore, an enquiry was made covering about 2,000 workers in the rag-sorting industry. This represented a large majority, though not the whole, of the men and women employed on rag-sorting in Belgium. The industry is not for the most part carried on in large undertakings, but in a very considerable number of small depots, each of which employs only two or three workers. The conditions of a large factory are therefore absent, and the health conditions of the workers closely approach those of the general population.

Owing to the disagreeable nature of the industry the workers mostly leave it after a comparatively short time. A small class of persons engaged in independent business form an exception.

There is no special evidence to show that rag-sorting is an unhealthy trade. Possibly the fairly high level of health conditions must be attributed in part to the fact that many of the workers enter the industry at a comparatively late stage in their lives. Or again, it may be that the trade is regarded as a bad one and therefore persons of delicate physique avoid it. Rag workers reach a high standard of general physical development, as their work requires considerable muscular strength. A comparison with the flax industry showed that the general state of health of workers in the rag trade was considerably above that of workers in the flax trade, even in the least unhealthy branches of that industry.
France. — The effect of the trade in rags and old clothes which had not been disinfected on the spread of smallpox and other infectious diseases was investigated in 1879 by Gilbert. This author also states that during an epidemic the district of Paris, in which the largest number of rag-sorters and old-clothes dealers lived had two or three times as many deaths from smallpox as other parts of the town.

In 1885 Pouchet reported four cases of infection among rag workers, and Blaise quotes the following figures collected by Ballestre (of Nice) for the years 1885-1887: 73 smallpox cases out of a total of 186 among the general population of Nice over the same period and 29 diphtheria cases out of a similar total of 169. More than one-third of the cases of measles which were notified occurred near rag depots.

A detailed report dealing with the economic and social aspect of the rag industry in Paris was published in 1903 by the German Paper Manufacturers’ Association in the next year, 1888, showed that the percentage of smallpox and anthrax among rag-sorters was 16 per cent. and their general morbidity rate 45.3 per cent., while the respective figures for other workers in the same factories were 10.7 per cent. and 30.3 per cent.

Dreyfus, in Weyl’s treatise on industrial diseases of 1897, contributes a chapter on the subject. His figures, however, only cover sixty workers employed in a rag-sorting workshop in the country during a period of seven years; 7 per cent. per year of the workers suffered from injuries to the skin and 35.5 per cent. from other diseases, giving a total of 42.5 per cent.

Germany. — In 1877 Ordmann pointed out, in connection with the smallpox epidemics of 1882-1884, the influence of the rag trade and the handling of wool from Buenos Ayres on the spread of smallpox in Germany. In 1880 there was an epidemic of smallpox among rag-sorters in Abenheim, Hesse, which was caused by rags imported from Marseilles, where there was a serious epidemic. In 1897 Filkenburg mentioned the fact that rag-sorters had been known to contract erysipelas from rags, at the same time stating that smallpox and anthrax constituted more serious dangers.

In 1884 a statistical enquiry was made into health conditions in the Saxony paper factories, which showed the comparative prevalence of disease among rag-sorters and other workers in these factories, and revealed not only that the general frequency of disease was very much higher among the rag-sorters than among the other workers in the same factories, but also that this higher disease rate was overwhelmingly due to respiratory trouble.

A more general enquiry carried out at the suggestion of the German Paper Manufacturers’ Association in the next year, 1885, showed that the percentage of morbidity from disease of the respiratory organs among rag-sorters was 16 per cent. and their general morbidity rate 45.3 per cent., while the respective figures for other workers in the same paper factories were only 10.7 per cent. and 30.3 per cent.

Wittgen writing in 1913 gave a detailed account of health conditions among women employed in rag-sorting rooms in Hanover. From an examination of the medical records of the local health insurance society, which cover the four largest rag-sorting workshops, Wittgen collected figures covering 1,602 persons (including an average of 267 workers per year). The following figures are Wittgen’s percentages per 1,000 women employed in the Hanover rag industry from 1907 to 1912 (only such disease as involved loss of working time or medical treatment was recorded):

<table>
<thead>
<tr>
<th>Type of disease</th>
<th>Num. of cases of disease</th>
<th>Num. of days of illness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influenza</td>
<td>129</td>
<td>3,194</td>
</tr>
<tr>
<td>Pulmonary tuberculosis</td>
<td>26</td>
<td>1,634</td>
</tr>
<tr>
<td>Acute rheumatism</td>
<td>11</td>
<td>513</td>
</tr>
<tr>
<td>Diseases of the blood</td>
<td>318</td>
<td>1,125</td>
</tr>
<tr>
<td>Diseases of the skin</td>
<td>50</td>
<td>1,383</td>
</tr>
<tr>
<td>Rheumatism</td>
<td>110</td>
<td>2,379</td>
</tr>
<tr>
<td>Other diseases of the motor system</td>
<td>19</td>
<td>449</td>
</tr>
<tr>
<td>Diseases of the circulatory system</td>
<td>20</td>
<td>443</td>
</tr>
<tr>
<td>Diseases of the nervous system</td>
<td>28</td>
<td>616</td>
</tr>
<tr>
<td>Diseases of the ears</td>
<td>3</td>
<td>66</td>
</tr>
<tr>
<td>Diseases of the eyes</td>
<td>15</td>
<td>223</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>7</td>
<td>953</td>
</tr>
<tr>
<td>Other diseases of the respiratory system</td>
<td>177</td>
<td>4,140</td>
</tr>
<tr>
<td>Diseases of the digestive system</td>
<td>137</td>
<td>2,973</td>
</tr>
<tr>
<td>Disturbances of menstruation and pregnancy</td>
<td>39</td>
<td>979</td>
</tr>
<tr>
<td>Diseases of the genito-urinary system</td>
<td>51</td>
<td>1,673</td>
</tr>
<tr>
<td>Other diseases</td>
<td>238</td>
<td>4,049</td>
</tr>
</tbody>
</table>

| Totals | 1,194 | 95,681 |

Wittgen further states that, while the number of cases of sickness for the five years per 1,000 rag workers in Hanover was thus 1,124, it was only 589 per 1,000 for all workers in the Hanover insurance society (630 per 1,000 over the same period for all workers on the books of the Leipzig society).
Brerina reports that, for the period 1920-1922, influenza and diseases of the respiratory organs reached a high percentage in the rag-sorting industry. In a large rag-sorting workshop in the district of Trier, there was found in 1922, amongst 397 persons employed, 190 cases of illness, 90 per cent. of which were due to the following causes: influenza, bronchitis, sore throat, pulmonary catarrh, itch and carbuncles.

In the State of Hesse there were reported for the same period, amongst rag-sorters, numerous cases of pulmonary diseases (chiefly of which were tubercular) and also of skin diseases.

An enquiry effected in Prussia (1925) by the factory inspectors related to 36 establishments (50 in 1924) giving employment to 972 persons (791 in 1922). Health conditions in these establishments left much to be desired. Sorting was often done in the store-rooms; the sorting tables were rarely provided with an adequate mechanical exhaust device, and when there was one, the workers complained of the draught created by the apparatus. The employers rarely provide working clothes for their workers. The use of sorting tables providing for removal of the heavy dust, which falls into a box situated under the table, and the installation of dust-exhaust devices at the level of the work table to remove the lighter dust, even in accordance with experience to be a better system from the point of view of practical necessity.

It is not rare for the workers to find stones, animal dung and even dead cats amongst the rags.

The dust raised during the process of sorting naturally comprises elements derived from such material. In general the dust is of an organic nature, rich in albuminoids. The nature of this dust might provide an explanation of the general, though not specific, immunity acquired by these workers. In fact, young apprentices suffer at the commencement of the work from attacks of fever (carders' and sorters' fever) which may well be due to the action of the proteins.

The workers examined are generally aged workers who have been engaged for many years in the establishments. The labour turnover is relatively slight. There were found, in fact, 42 per cent. of the workers between forty and fifty-nine years of age, and 7.6 over sixty.

The state of health of the workers was satisfactory. In 1924, 91 out of 397 men employed had been ill, and 273 out of 605 women (791 in 1922) employed had been ill, and 273 out of 605 workers between forty and fifty-nine years of age, and 7.6 over sixty.

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Great Britain. — At one time the rag industry in Great Britain was concentrated in the town of Batley, in Yorkshire, which was known as the 'Rag Metropolis' because it dealt with rags from all over the world. An interesting description of the industry is given in an article by John A. E. Stuart (1902) in Oliver's treatise on dangerous occupations.

In 1876 B. W. Richardson quoted figures given in an article published in 1859 by J. J. Murray, of Edinburgh, who had carried out an enquiry into conditions among Edinburgh rag-sorters and other rag workers. The enquiry showed the remarkable fact that infectious disease was almost non-existent among the workers, who only complained of chronic cough and irritation of the throat owing to the inhalation of dust.

In 1888 Parsons gave an account of a serious epidemic which had broken out during the preceding year in two paper works, and eight other epidemics which occurred between 1875 and 1881.

Three other epidemics also occurred in paper works during 1844.

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disinfected hospital refuse before it was sent to rag dealers.

Italy. — An enquiry undertaken in 1886 by Corradi showed that rag workers did not suffer from any special diseases except those due to the dusty nature of their work. Corradi considered, however, that there was a possibility that bacilli with more power of resistance might be diffused by means of rags.

A more recent enquiry by Giglioli (1914) into the rag industry at Pontorme also showed that these workers are exposed to very little risk even if the industry is carried on at home, probably because in Italy the work is done in the open air. In the opinion of Professor Loriga (1923), the rag industry does not seriously endanger the health of the workers, and this view was confirmed by medical examination of the women employed in the sorting rooms. He observed some cases of injury to the fingers, but whitlow and phlegmon were not more common than among other workers.

For Allevi's enquiry, see article "Scavengers".

Netherlands. — Several cases of smallpox were reported from paper factories in Maastricht. At a shoddy factory in Lemiers 26 workers out of a total of 45 contracted typhus in some cases, whereas workers who have been slightly injured by objects found among the rags have died of tetanus.

At the Health Congress held in The Hague in 1884 Ruych reported 40 well-authenticated cases of smallpox contracted in the rag industry in the years 1870 and 1871.

According to the reports of the Dutch Factory Inspectors for 1907 and 1908 many rag-sorters suffer from diseases of the respiratory system and are predisposed to tuberculosis.

The inspectors state that in properly equipped workshops sanitary conditions are more satisfactory, but that even there adequate hygienic measures are not always taken.

Switzerland. — A United States investigation, Whittington, written in 1887, mentions the account given by Sondernger, Biemer, and Zehnder of a small epidemic of cholera (17 cases with 11 deaths) which occurred in 1867 in a paper factory at Kriessettr. This factory imported rags from Zurich, where a serious cholera epidemic was raging at the time.

Schuler and Burkhardt ascertained by an enquiry published some years ago that the proportion of disease among rag-sorters to disease among other workers in the paper industry was 1.6 to 1 for diseases of all kinds and 1.4 to 1 for diseases of the respiratory system.

The Factory Inspectors' Report for 1916-1917 points out that the tearing of old and frequently dirty rags by machinery is liable to be dangerous, because wounds might be caused by pieces of metal contained in the rags.

Union of Socialist Soviet Republics. — An enquiry carried out in 1921-1922 in four rag-sorting establishments at Petrograd showed conditions in these to be extremely bad. The work was effected in small courtyards or in open sheds, in which the women workers were exposed to all weathers. The women worked sitting on the ground or on heaps of dirty rags, were neither provided with working clothes nor soap nor towels. The women sorted on an average 240 kg. of rags (large pieces) per day. In addition to this work, they had also to open the bales of rags, which arrived at the depot in carts.

In February 1922 these workshops employed 220 women rag-sorters. The work done in the workshops years for export. The rags arrived from different parts of the country: Southern Russia, Siberia and Central Russia.

Medical examination of 1511 women workers revealed: 66 cases of anaemia, 31 of digestive trouble, 33 of chronic bronchitis, 35 of contagious skin diseases, 31 of eye disease, 32 of muscular pains in the legs, the arms and the back.

United States. — In 1875 the Lewis brothers reported the occurrence of cases of smallpox, measles, and other infectious diseases in a New York paper factory. They examined statistics referring to 23,170 rag-sorters for a period of twenty-five and a half years. In 1887 C. F. Whittington reported cases of infectious diseases such as measles, scarlet fever, and erysipelas in small rag works, but he did not find any cases in the large rag works of the United States.

More recently, in 1913-1914, an enquiry covering twenty paper factories was carried out in the State of Ohio. The workers in question employed 274 workers, including 203 men, on rag-sorting. The workers were generally unwilling to make any statement, but some complained of the evil effects of dust, of their working hours, and of unsanitary conditions. It was not possible to collect any figures of sickness among rag-sorters either at the time of the enquiry or in previous years.

An enquiry covering nine paper factories, which employed 153 workers, including 128 women, showed that their state of health appeared somewhat poor. There was a great prevalence of symptoms obviously due to the irritation of the mucous membranes by dust.

Hoffman points out that, in general, unsatisfactory statistics on this trade are available; he gives the following figures (1918) of the distribution of deaths by age-groups from respiratory diseases among 3,926 rag-sorters (1,220 men and 1,706 women):
Pathology

The system is protected from dusty disease by the natural means of defence of the respiratory system, namely, the ciliated epithelium and the involuntary movements which cause coughing and sneezing and thus eliminate the foreign dust. If, however, dust is present in excessive quantities, it gives rise to ordinary catarrh, which is easily cured when the patient ceases to breathe dust, but which gradually develops into chronic catarrh if the patient continues to engage in a dusty occupation. Chronic catarrh damages the respiratory organs in such a way that they are unable to resist certain diseases such as tuberculosis and pneumonia.

On the other hand, attacks of fever of an acute form — rag-sorters' disease — are often met with amongst rag-sorters (chiefly amongst young workers and those who are new to the trade). The symptoms of this illness are similar to those of serious bronchial catarrh and influenza. Amongst old workers there are found cases of bronchitis, signs of emphysema, obstructions in the ears with temporary deafness, cases of blepharitis and particularly a characteristic form of acne due to dust from the rags.

The infectious diseases most frequently met with amongst the workers in the rag industry are: smallpox; anthrax and erysipelas. It would, however, appear from statistics that cases of anthrax are very infrequent. There should also be noted cases of tetanus and internal anthrax (Bradford), of measles and scarlet fever and more rarely of plague and cholera, as well as irritation of the mucous membrane due to dust.

Hygiene

Rag depots are considered by legislative authorities to be dangerous from a health point of view, for it is undoubtedly true that they present serious disadvantages and even risk: foetid odours due to the fact that they sometimes include animal bones and skins as well as all sorts of organic material in a state of decomposition; danger from fire resulting from the accumulation of old papers, old linen and cloth more or less impregnated with grease; danger of contamination when they include products which have not been washed or disinfected. They must be away from the neighbourhood of dwelling houses, they must be well ventilated; all windows and openings communicating with the street or neighbouring properties must be kept closed; rags must not be sorted or dried in the street; the floors of the store-rooms and workshops must be watertight; bones and the skins of animals may not be stored without special permission; the store-rooms and workshops must have good natural light, and all artificial lights (even if not in the rooms themselves) must be surrounded by glass and wire-netting if electric light is not installed. All exposed wood must be covered with plaster. The premises must be frequently washed with plenty of water and with solutions of chloride of lime or formalin. There must be an abundant water supply for the cleaning of the depot and for use in case of fire. The rags must be stored in bales not more than 3 metres in height and 2 metres in length, separated from other dangerous goods by an interval of at least 50 cm., and different materials such as paper, rags, etc., must be stored separately.

Other regulations contain the following provisions: whitewashing of the walls with a waterproof solution or with lime (in the latter case this should be done at least annually); prohibition of storing rags in a disgusting or putrefying condition or coming from localities in which infectious diseases have occurred; transport of rags in tarred sacks and in specially closed vehicles in conformity with the local municipal provisions as regards hours, etc.

The principal danger is from dust, but "shoddy fever", "flock fever", and other forms of respiratory disease do not seem to be dangerous illnesses; they apparently resemble mild attacks of chronic influenza. The only way that of infection is greatly reduced by the effects of desiccation on many disease germs. Those germs which resist desiccation are well known, and the danger from them is usually the subject of preventive legislation, which covers the rag trade in common with other trades handling such goods. The special danger arising in the rag trade from the infectious nature of linen rags derived from hospital waste has for the most part been eliminated by regulations making disinfection of such waste compulsory before sale.

At the same time enormous volumes of dust arising in the course of the sorting and shredding processes, as well as the risk from germs inherent in the dirt of the soiled rags, the vast mass of which do not come under the class of dangerous or infected goods, seem at first sight to create such risky conditions that it can hardly be re-
garded as surprising if special precautions are imposed in this trade. The extent to which these precautions should apply has been considerably discussed. Expense is a large factor; also the nature of the exact process to be applied for disinfection — dry, wet, or steam under pressure.

The precautionary processes advisable fall into three stages — thrashing, disinfecting, and drawing off the dust during the final processes of shredding, etc. Thrashing, which means elimination of the initial dust by mechanical processes, can only be done by machinery the fact that such machinery cannot be installed except in a factory is a good reason for prohibiting rag-sorting as a home trade. The thrashing machine should be provided with an efficient exhaust system and the dust should be removed and burned.

It is sometimes objected that if rags are dusted by machinery before sorting they suffer a loss in weight, which some manufacturers estimate at 20 per cent. The operation of dusting by machinery cannot, however, be considered as a reliable means of removing disease germs from rags. Disinfection is clearly the only certain protection against infection. As the danger is particularly great when the bale is opened, disinfection would require to be carried out before this operation. It is, however, well known that the highly compressed bales in which rags are usually packed cannot be satisfactorily disinfected right through. None of the methods proposed for disinfecting the contents of the bale without opening it have proved really satisfactory, and it is therefore necessary to disinfect after the bales have been opened.

Some authorities advise that the rags should be moistened or impregnated with a disinfectant solution before sorting. There has been suggested a solution of chloride of lime at the rate of half a litre per square metre of surface and 50 cm. thickness, followed subsequently by thorough disinfection by a dry process. Another alternative suggested is soaking the rags in milk of lime.

Carbolic acid is the disinfectant preferred in spite of its high cost, for solution of sublimate soon loses its effects by contact with metal objects and may be rubbed in with wool. It is not practicable to treat rags with boiling lye or with chlorine, but other processes, e.g., the now frequent use of formaldehyde vapour, may certainly produce satisfactory results. Whatever solution is used, however, rags which have been treated in this way require a long and expensive drying process.

Industrial experience has shown that the treatment of rags by wet processes to prevent dust is not to be recommended, in the first place because it is liable to rot the rags, in the second place because unpleasant effluvia are produced. The best method is disinfection by steam under pressure. This process has been in use for some time (as early as 1897 in New York). At the present time, however, authorities are unanimous in recommending the process. Drying from the effects of steam can easily be carried out in the apparatus used for disinfection. The technical difficulties are so great and the cost of disinfection so high where chemical disinfectants are employed that Loriga does not see the practical possibility of recommending disinfection of rags to prevent danger from infection which is relatively slight.

In municipal establishments for the destruction of dust in a number of towns in Great Britain, Germany and the United States, it is already customary to disinfect the rags by steam under pressure or by dry heat at 110° to 120° C. before they are sent to the depots. The practice may be generally recommended.

Some authorities who are in favour of disinfection consider that it should not be left to the dealers, as they cannot guarantee its efficacy. If really adequate disinfection is to be ensured it should be carried out by the public authorities. This, however, can scarcely be considered practicable.

After the rags have been thrashed, and, if necessary, disinfected, they are sent to the sorting rooms.

Here some investigators have recommended masks, but these are of course uncomfortable and impractical when work is carried on, as in this case, for a long period. It has also been recommended that gloves should be worn. It is more usual, and generally esteemed efficacious, if the sorting and shredding tables are provided with exhaust apparatus fixed under a wire netting for drawing off the dust.

Some manufacturers have set up apparatus by which dust is extracted upwards. In this case the nozzle is above and in front of the knife. This system, however, has not produced satisfactory results in comparison with the down-draught system. The heavy dust is not removed from the workroom, and only that part of the light dust which is produced between the knife and the exhaust nozzle is removed, while that part which is produced near the mouth of the operator remains in the workroom.
Manufacturers were, for a long time, unwilling to place open stoves in rag-sorting rooms, owing to the danger of fire, and did not wish to incur the expenditure involved in installing hot-air and hot-water heating systems. One manufacturer, however, realising the inconvenience which arose in winter from the draught created by the exhaust fans, at once installed a steam-heating system in the sorting room (France).

Workers should not be employed unless they have been vaccinated, and vaccination should take place every five years. Persons who have any open sores on their hands and face should be temporarily forbidden to work. Workers should be informed of the dangers to which they are exposed.

Special working clothes should be worn, and undertakings should be obliged to provide properly equipped washing and cloak rooms.

LEGISLATION

The employment of women in collecting and washing rags and bones is prohibited in Argentina, and in France in the operations of tearing and shredding rags, as well as employment in workshops where acid fumes are given off during treatment of rags by hydrochloric acid.

The employment of boys under sixteen years of age is prohibited under similar conditions to those for women in Canada (Quebec), Great Britain, the Netherlands, Spain, Switzerland and the United States; the employment of young persons under fifteen years of age is prohibited in Italy and in Japan; of young persons under eighteen years of age in Denmark, Finland, France and Norway. The employment of young girls under eighteen years of age is forbidden in Canada (Quebec), Denmark, Finland, France, Great Britain and Norway and under twenty-one years in Italy, Japan, Spain.

In Germany an Order of 8 December 1900 regulates the employment of young persons in the manipulation of fibre, hair or rags unless dust exhaust apparatus is installed. This condition is also exacted by other legislative provisions (France, Italy). Section 4 of the German Act of 30 May 1914 prohibits the employment of young persons in the shredding of rags. The earliest measures prohibited by law were intended to prevent infection of the general population by germs from soiled rags. In Austria the Act of 28 June 1870 laid down that rags contaminated with infectious matter must be burned.

In 1901 the Austrian health services recommended that the dust should be withdrawn by machinery from rags before sorting, the machine for dust removal to be provided with an exhaust device, and that the dust collected in filters should be precipitated into water or burnt.

At the sorting tables evacuation of dust was to be effected by the downward draught method, and sorting of rags in the workers' homes was prohibited.

In Great Britain section 126 of the Public Health Act of 1875 imposed a penalty upon any person who "gives, lends, sells, transmits or exposes without previous disinfection any bedding, clothing, rags or other things which have been exposed to infection by any dangerous disease".

In Great Britain the committee appointed to study the risk from anthrax infection in industry concluded that it was advisable to recommend washing and mechanical dusting of all rags prior to any manipulation with the exception of clipings of new material. Its recommendations include also the provision of adequate facilities for personal hygiene of the workers and the application of suitable means, mechanical or other, for reducing to a minimum the production of dust and assuring its removal from the workroom.

The periodical medical examination of the workers was likewise recommended.

The French Decree of 27 May 1853 made it temporarily compulsory to disinfect imported rags. The Decree of 15 April 1855 rendered this measure permanent.

In 1890 the Consultative Committee of Public Hygiene of France approved of the strictest possible regulation of the rag industry and affirmed the necessity for protection of public health in this sphere. The Decree of 1 October 1913 prohibits the utilisation of hospital refuse. The Academy of Medicine, after hearing a report by Wurtz in 1914, insisted on the demand for the prohibition in Paris and the suburbs of rag-sorting in courtyards or in the street, household refuse to be dealt with exclusively in municipal institutions for dust distribution and incineration, and dust and refuse removed in such a way that no dirt or dust may be scattered in the street or in the air.

In Italy a Circular of the Ministry of the Interior, dated 15 March 1919, prohibited the use of rags and waste from hospitals in the clothing trade without previous disinfection.

In Great Britain the Anthrax Prevention Act of 1919 empowered the authorities from time to time as occasion arose by Order-in-Council to control the importation and also to order the disinfection of goods liable to be infected with anthrax, such goods to include rags.

Amongst legislative measures applied may be recalled that of Austria (Order of 25 September 1911) relative to paper factories; paragraph (b) deals with the use and treatment of rags and includes a series of hygienic measures in connection with the various processes; compulsory vaccination of the workers, exclusion of persons suffering from respiratory diseases and cutaneous lesions.

In Belgium the Royal Order of 4 February 1895 provides for vaccination of workers employed in handling rags and the Danish Regulation concerning textile
laboratories and dated 23 January 1908 also contains hygienic measures relative to the manipulation of rags.

A Circular issued by the Prussian Ministry for Trade and Commerce in 1894 (confirmed by a later Circular dated 25 February 1895) contains very detailed regulations. An Order concerning the installation and working of rag-sorting workshops was issued on 28 March 1928.

In Norway, the Resolution relative to such depots is dated 26 November 1925.

The carrying on of the trade as a home industry is, from the point of view of the health expert, even more important than factory work. In the rag-sorter’s home thrashing cannot be undertaken by machinery, nor can exhaust apparatus be fitted to tables. In 1915 the authorities in Saxony discussed an Order calculated to prohibit the practice of the trade as a home industry, except in the case of rags which had been previously threshered. It was pointed out that any form of thrashing or of disinfection applied to the home industry would be very expensive and even then not entirely efficacious. Even after thrashing the cutting and tearing of rags causes clouds of dust which can be dealt with in a factory in which exhaust apparatus is installed, but which in the worker’s home would rise each time any person present made the slightest movement. Eventually the Order which in the worker’s home would rise each time any person present made the slightest movement. Eventually the Order was put within the competence of the Federal Minister of Labour. However, it was pointed out that any form of thrashing or of disinfection applied to the home industry would be very expensive and even then not entirely efficacious.

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In Finland a resolution dated 13 December 1924 regulates the work of sorting and shredding rags; in U.S.S.R. a compulsory Order dated 3 November 1922 dealing with paper factories contains measures for the protection of workers engaged in the sorting and shredding of rags.

Pulmonary affections occurring amongst workers in the trade as well as tetanus are subject to compulsory notification in the Netherlands. Erysipelas, anthrax, plague and smallpox are compensated under Japanese law.

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### Red Lead

**French:** Minium. — **German:** Mennige oder Minium. — **Italian and Spanish:** Minio.

**CHEMISTRY**

Red lead (Pb₂O₄), of which the composition varies between PbO₂, 2PbO, and Pb₂O₃, is the red oxide of lead. It is the product of the combustion of lead metal and consists of a mixture of lead dioxide and lead oxide. The quality depends on its more or less perfect oxidation and the purity of the lead employed. The red lead obtained from the calcination of white lead (a process employed in Great Britain and one giving a more beautiful product than when lead is used as the starting point) bears another name: orange lead (French: mine orangé, rouge de Paris, orange minéral, cinabre de Saturne, etc. — German: Orange Mennige. — Italian: Minio aranciato. — Spanish: Minio arangiado).

Red lead has the appearance of a fine powder, heavy, orange-red in colour, the shade varying with the method of manufacture; it is the richer in colour and the content in peroxide is raised. On slight application of heat the colour becomes paler. Calcined in the air the red lead changes to brown, then to yellow and becomes converted into litharge. It is insoluble in water and dilute hydrochloric acid; it dissolves in strong boiling acid, giving off chlorine and forming lead chloride. Weak acids decompose it. Its covering power is excellent, but it is poisonous and is blackened by hydrogen sulphide. The commercial red lead of highest quality only contains 97 per cent. of pure red lead (Pb₂O₄); this content can fall to about 60 or even 40 per cent. Further, very often, fraudulent addition is made of other compounds, such as native barytes, when ground and tinted red, aniline colour, pounded brick, colcothar, chalk, clay, gypsum, lead sulphate, colours with a basis of iron or other substances in which the shade is intensified by using artificial organic colours (coloured red by eosin, cinnabar, and vermilion substitutes made up of a mixture of red lead, baryum sulphate, sulphate and carbonate of lead and eosin, sold under fancy names).

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At the present time red lead has a strong competitor in "grey" red lead, or "arcanol", a lead colour containing the latter partly in finely separated, partly in oxidised condition. The advantages gained are said to be increased output, possibility of preserving in good condition for an unlimited period, small oil consumption, excellent drying capacity, efficacious protection of metallic objects against rust and impermeability of the dry paint to water.

**MANUFACTURE**

Metallic lead heated to 450 to 500°C, in contact with air on the floor of a reverberatory furnace becomes converted into protoxide or massicot. The layer of oxide formed requires to be continually removed and a too high temperature which would convert the massicot into litharge — less satisfactory for the manufacture of red lead — must be avoided. The red lead is then removed, ground with water and filtered over a metal sheet. After drying it is again oxidised in the presence of much air at about 30°C. After withdrawal from the furnace it is cooled, the massicot then having a greenish colour which changes to pink or yellow according to the amount of oxygen present.

The oxidation of the massicot is effected in refractory muffle furnaces which are charged either by hand or mechanically. The massicot is fetched on a truck which is placed against the door of a furnace and provided with a ventilating flue. The muffles are placed in the upper part of the furnace where the massicot is made, thus utilising the heat expended in the manufacture of the red lead. The oxidation of the massicot can be carried out also on the flat floor of a reverberatory furnace heated by gas. The massicot requires to be frequently raked in order to bring fresh surfaces into contact with the air.

The yellow tint of the massicot turns to red on the formation of red lead.

Minium is also made commercially by super-oxidising the massicot with nitrate of soda in accordance with the formula: 3 Pb O + Na NO₃ = Pb₃ O₄ + Na NO₃. The sodium nitrate is separated from the red lead by washing, concentrating, and successive crystallisation.

The minium obtained is washed, dried and ground into a fine powder, sieved and packed in barrels or sacks.

**Dangers.** — The first processes are less dangerous than the later ones. During the melting, however, the workmen are exposed to the risk of inhaling lead fumes given off on opening the furnace doors. The use of ventilating hoods only slightly improves this. "Rabbling" and feeding the furnaces with massicot for conversion into red lead are very arduous and give similar risk. "Rabbling" can be done mechanically by stirrers. In Great Britain now the operations are done automatically (Chester method) and the mechanics are the persons who run risk in attending to the efficient working of the plant.

The processes of removal from the furnaces, drying, grinding, sieving, filling of small cases by hand, placing of these in reserve storage, and and packing of barrels by hand naturally expose the workers to the risk of poisonous dust if not carried on with the necessary precautions.

**USES**

It is used as a jointing paste for pipes and boilers, as the first coat of oil paint for the preservation of iron (railways, bridges, ships, etc.). It is used in the painting industry, in the manufacture of accumulators, in the pottery industry, for backing mirrors to prevent oxidation of the metallic film, in the manufacture of glass, crystal, coloured papers, fine colours, matches, in dyeing, for colouring wax, etc.

**TOXICITY**

Although certain writers consider the toxicity of red lead as minimal, most think it is, on the contrary, as toxic as white lead. The danger is sufficiently important for attention to be directed to it: as a matter of fact, in a German red lead factory, in spite of the precautionary measures taken, 1.2 milligrammes of lead, estimated as oxide of lead, was found in 191 litres of air in the sieving room. In another factory, on analysis of the dust being made at three different points, near the grinding rolls and close to the sieves and furnaces, a percentage of dust reckoned as oxide of lead was found amounting to 64.8, 73.8, and 81.8.

Workmen using red lead, either as colours, jointing paste, etc. (see above), are also exposed to the danger of lead poisoning.

**STATISTICS**

*Austria.* — In 1913, the Factory Department called attention to the danger from the use of spraying red lead. According to Teleky, in 1913, 50 per cent. of painters on steel work were affected with lead poisoning.
Belgium. — The State Railway Company reported cases of saturnism among their employees habitually engaged in handling red lead.

France. — See "Lead, Poisoning by".

Germany. — Good organisation from the technical and hygienic point of view in a red lead factory enabled the lead poisoning risk to be much reduced between 1899 and 1903. Among an average of 42 workers, there was only one case of colic and five of gastritis. In another works, on the contrary, where the conditions were bad, during the same period and with an average of 28 workmen, there were 18.6 cases of colic (35 in a single year) and 4.2 of gastritis. According to Wächter, red lead comes second to white lead as a cause of cases of saturnism.

Prussia. — Between 1914 and 1918 a remarkable diminution of cases of lead poisoning in steel constructional work was achieved by the use of substitutes (red oxide of lead). In the same country in 1919, 99 slight cases occurred in a factory where locally applied exhaust ventilation for the dust was considered satisfactory and where alteration of work had been arranged.

Great Britain. — According to the report of the Medical Inspector of Factories, of 108 cases during the 10 years 1900 to 1909, 47 affected furnace workers, 43 packing and sieving, and 16 other workers. Of the 108 cases 30 were severe, 31 moderate, and 47 not severe. The symptoms were distributed as follows: 87 colic, 28 anaemia, 8 spastic paraplegia, 9 encephalopathy and 13 rheumatism. Collis found, in a group of factories visited between 1905 and 1909, and employing 171 persons, that 5 per cent. were attacked by plumbism and 13 rheumatism.

Between 1910 and 1923 the number of cases in the manufacture of red lead (as distinct from manufacture of litharge and white lead and also use of red lead) was 1914, i.e. an average of 9 cases per annum.

According to Oliver, a quarter of the cases of lead poisoning by red lead show severe symptoms, and the English statistics rather confirm Layet's opinion, namely, that red lead provoked more easily than other lead compounds severe and fatal forms of lead poisoning.

Netherlands. — Poisoning cases were reported in the metallurgical industry.

United States. — According to Hamilton, the risk was very small in many factories where there was little escape of dust and where efficient mechanical methods offering adequate protection against fumes and dust had been developed. On the contrary, in badly organised work, especially where hand work was done, the risks were even greater than in the white lead works. Thus, in one factory, during 16 months there were 7 cases of lead poisoning among 12 workmen, as compared with 14 among 65 in white lead works; that is, a proportion of 58.3 for red lead as against 22.5 for white lead. The duration of employment of the workpeople was less than a year. Severe cases of encephalopathy have been reported (three) amongst workmen employed in the dry rubbing of surfaces painted with red lead.

Pathology

See article "Lead, Poisoning by".

Hygiene

The precautionary measures which follow apply equally to litharge and massicot. The furnaces should be built either in the open air or in large workrooms with free ventilation (Belgium) or provided with efficient exhaust arrangements (Great Britain), as also should all operations for the cooling of litharge and red lead. In "rabbling" and removal of the material from the furnaces, the workmen ought not to be exposed to fumes and dust. If the furnaces are not in the open air, exhaust hoods with strong draught should be placed above the working doors (Belgium, France, etc.). In Germany all newly constructed furnaces must have mechanical charging, and from 1 January 1925 furnaces which have no mechanical charging and emptying devices must be withdrawn from use.

In order to avoid escape of the dust, the massicot should be slightly moistened, which can be readily done if the drying is not carried too far. As an additional precaution, the workmen may wear a wet sponge over the mouth. In the same way, removal of the material from the furnace can be done by mechanically-worked shovels. The material should be emptied into a partially closed trolley connected up with the exhaust and moistened beforehand.

During wet grinding and crushing of the material (when either wet or in closed apparatus) and removal of the massicot from the bins, actual contact of the hands with the oxide or risk from splashes should be avoided.

Pulverising and sieving should be done in apparatus hermetically closed, which should not be opened until a sufficient time has been allowed to elapse for all dust to have settled. Transport, packing and settling should be done in a manner preventing the raising of dust. The floor of the workroom should be in sound condition and kept damp if necessary. The material should be conveyed to the furnaces in a moist condition or in closed receptacles so as prevent the escape of dust into rooms where work is being carried on. The clearing of sacks which have contained lead com-
pounds should either be done when well wetted or in closed apparatus. Spells of work at the furnaces, etc. (Great Britain) should not last for more than three hours without a break of half an hour, nor should furnaces be approached except when ventilation is good.

To-day new methods enable red lead to be manufactured without escape of dust and without contact with the workers' hands. The lead is converted into amorphous protoxide (massicot) instead of crystalline protoxide (litharge). The blocks of lead are transported automatically from the factory entrance to the furnace. The furnace is provided with a ventilating hood. The interior of the vat has an air pressure lower than that of the outside air and the mixing of the lead is done automatically. The lead-oxide dust enters into two circuits according to whether it is fine or coarse dust. The coarse dust falls by force of gravity and is led off by a screw to the silo. The fine dust, carried off by the current of air, passes along an endless screw to the silo. The silo house contains filters and its interior has an air pressure lower than that of the outside air and the mixing of the lead is done automatically. The lead-oxide dust enters into two circuits according to whether it is fine or coarse dust. The coarse dust falls by force of gravity and is led off by a screw to the silo. The fine dust, carried off by the current of air, passes along an endless screw to the silo. The fine dust, carried off by the current of air, passes along an endless screw to the silo. The fine dust, carried off by the current of air, passes along an endless screw to the silo. The fine dust, carried off by the current of air, passes along an endless screw to the silo. The fine dust, carried off by the current of air, passes along an endless screw to the silo. The fine dust, carried off by the current of air, passes along an endless screw to the silo.

This is then taken by a bucket conveyor to the silos and eventually by a funnel to the barrels. The packing is accomplished without any escape of dust and without contact with the workers' hands. This is, roughly, the modern method used in a French red lead factory described by Tournois (1928) in which the number of cases of lead poisoning recorded among the workers were 5 in 1924, 11 in 1925, 46 in 1926, 4 in 1927, and 2 in 1928. The new equipment was installed in 1926.

Personal hygiene should be encouraged in every way, as in all dangerous trades, by provision of overalls, respirators, a messroom, and washing accommodation. Alternation of employment should be practiced in the case of the most dangerous kinds of work.

Periodical medical examination should be carried out on persons employed in the manufacture of red lead, litharge and massicot; this is required monthly in Great Britain, Netherlands, and the States of California, New Jersey and Ohio; quarterly for the lead industry in Austria, France, and Yugoslav; and bi-monthly or even weekly in Germany.

Substitutes. — Pure red lead is one of the best pigments for painting metal, with the special object of protecting it from rust. Well prepared it has good covering power, leaving a solid surface. On account of its great natural density, however, weight for weight it does not yield coats so thick as those obtained with other colours. Analysis of a number of red leads (French, Belgian, and German) has shown that it contains from 73 to 97.2 per cent. of red lead, the remainder being litharge. The foreign substances which are commonly added in the commercial brands have been described. Efforts have been made to substitute for red lead other less poisonous substances in the painting of iron. From recent inquiries it would seem that colours with a basis of red lead are unnecessary for the priming coats on iron and even for all the coats except those to be placed under water. Thaus (1914) considered that red lead could be replaced by leadless colours, especially the superficial coats and where exposure to weather was not in question. These substitutes could be the oxides of antimony, manganese, iron, aluminium (bauxite), graphite, lithopones, different mixtures of paints, etc. (See article "Painting Industry").

LEGISLATION

In addition to general measures enacted for the protection of workers against dust and fumes and special regulations in force for red lead, litharge and massicot in Belgium (1910), France (1913), Germany (1916), Western Australia (1923), Victoria (1920) and in certain States of the United States (Illinois, 1911; New Jersey, 1914; Ohio, 1913; Pennsylvania, 1913). The principal requirements have been referred to in the preceding paragraphs.

For international legislation, see the article "Lead".

Women are excluded from the manufacture of red lead, litharge and massicot in Argentina, France, Germany, Great Britain, Japan, Lower Poland, Netherlands, Switzerland, and several States of the United States, etc.; pregnant women in Norway.

Young persons of 15 years are excluded in the State of Delaware, in Italy and Japan; under 16 years in Argentina, Belgium, Germany, Great Britain, Greece, Spain and most of the United States, etc.; under 18 years in Netherlands, Norway, Poland, Slovenia, Switzerland, under 21 years in
Refrigerating Plants
(Cold Storage and Cooling Processes)

Pennsylvania in packing dry red lead and litharge. Female young persons under 18 years are excluded in Greece; under 21 years in Belgium, Italy and Spain.

As to compulsory notification and compensation for occupational diseases, see the article "Lead Poisoning".

Bibliography


See also "Lead Poisoning" and the article "Poisoning".

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Refrigerating Plants

The cold storage industry is daily increasing in importance.

Cold is produced in laboratories and small industries through the absorption of heat by certain saline solutions — a scientific phenomenon established by Boyle in 1655 — and more particularly by the use of mixtures of salt and ice, according to Réamur’s discoveries in 1734 which Fahrenheit utilised for fixing the zero of his thermometer.

The cold storage industry, on the other hand, is based on the expansion of compressed gases and the evaporation of certain liquids which occur with the absorption of heat. These methods are founded on phenomena to which are attached the names of Faraday and Muschenbroek, and represent the principle underlying the Carré, Pictet and Linde machines.

The production of cold by expansion may in theory be effected with any gas, but in practice, air is mostly used in air-freezing machines. These machines were completely abandoned in the early days after they were first used, because of unsatisfactory results; but they have recently returned to favour with the new Leblanc process used in the high-pressure freezing machines of the Leblanc and Linde and the Leblanc and Vickers systems. The advantage of this type of machine, from the hygienic point of view, is that it uses nothing but a non-toxic product as its freezing agent, viz. air, whereas other freezing machines use gases.

From an economical point of view, steam as a freezing agent can only be made use of when large quantities of water are available for cooling at a cheap rate, or when it is essential to have a non-dangerous freezing agent, as for example on ships, where leaks in ammonia or sulphurous anhydride machines would make the holds uninhabitable. In such cases engines ejecting steam are used, as in the Gensecke system in Germany, and in the Leblanc-Westinghouse systems in other countries; these engines utilise the energy freed by ejecting a jet of steam in order to obtain aspiration and partial compression of steam or of a saline solution.

The production of cold by the evaporation of liquids is effected by means of machines in which are used as freezing agents chemical products which remain sufficiently volatile at the lowest temperatures attained, and remain liquid at the highest temperatures and pressures realised during the running of the machines. Among compounds volatile, but easy to liquefy, those most commonly used are ammonia, carbon dioxide, sulphur dioxide, and, in some particular conditions, ether, ethane, methyl chloride, ethyl chloride and numerous other products.

Gas freezing machines are worked on the principles of absorption and, as a general rule, of compression.

The first type — absorption machines — depend on the property belonging to certain liquids of being able to absorb, without undergoing any essential modification, gases or vapours coming from other liquids, and to give them up again in vacuo with the absorption of heat, i.e. with cooling of the surrounding atmosphere or of the particular refrigerating receptacle used. This system is only put to practical use in the case of the absorption of the vapour of ammonia by water and of the vapour of water by sulphuric acid. Experimenters have also tried to substitute absorbed substances, e.g. halogen compounds of various metals and chlorides of calcium, and have constructed absorbing machines...
Containing activated charcol as an absorbing substance.

The second type of machines are compression machines; they contain a compressor which by aspiration draws in a line of pipes, gas suitably arranged in a special carbon dioxide, sulphurous anhydride, or chloride of methyl, compresses it, and then sends it into a water condenser where it is liquefied and cooled. This freezing fluid is next passed into an evaporator connected with the aspiration pipe of the compressor. The compressor, by aspirating a certain quantity of gas, causes the evaporation of an equivalent quantity of liquid which involves the absorption of heat, i.e., the production of cold. Evaporators act as refrigerators by extracting from the atmosphere that is to be cooled the calories necessary for the production of the evaporation. They are generally composed of a bundle of large-sized pipes, through which the compressed and cooled gas passes. The vapours are then taken up again by the compressor and the cycle recommences.

Compression machines have some disadvantages, such as noise and shaking, unavoidable leaks from stuffing boxes, and the necessity for refilling which only make it possible to use them at a factory. Absorption machines do not possess these disadvantages, they are used in plants for domestic use, the use of which tends to become more and more extensive.

Freezing machines are calibrated in "frigories", one frigorie being the amount of heat required to be abstracted from a mass of 1,030 grms. of distilled water to reduce its temperature 1° C. The cold produced may be transmitted either directly by cooling the surrounding air, or indirectly.

In the first case, the bundle of expansion pipes is suspended from the ceiling or from the walls of the places to be cooled. This method of distribution, called "direct expansion", has the disadvantage of allowing a certain amount of humidity to remain in the atmosphere of the refrigerating chambers, which may be prejudicial to the preservation of some kinds of provisions.

In the second case installations of closed pipes, containing either cooled air or freezing brine, are used. The method known as the dry cold (frigid sec) consists in making chilled air circulate through a bundle of direct-expansion pipes, enclosed in a special place called a refrigerator. In these conditions the air driven forward by a fan becomes cooled on coming in contact with the expansion coil and the moisture it contains is deposited on the cold pipes in the form of rime. The air, cold and dry, is next taken up again and distributed by wooden channels suitably arranged in the places to be cooled. The air can be cooled still further by passing it over systems of brine pipes, or through a shower of powdered brine. In different cases the air can then according to requirements be cleaned from dust by filtration, dried, sterilised or oxygenated, and then pumped into the refrigerating chambers. Chilled brine can also be circulated in the places to be cooled. Either for cooling the air, or for circulation in the coils, plain water can be used instead of brine, when it is not desired to reduce below 0° C.; but, when it is solutions of chloride of calcium, of magnesium and of sodium are used, and, more rarely, solutions which are still more difficult to freeze, such as glycerine or alcohol.

Solid carbon dioxide has been tried for the last two years under the name of "dry ice" to replace ice in the refrigerator vans on railways.

It is obtained by decompressing liquefied carbon dioxide of which a third or more can then be collected in the form of snow. Carbon dioxide arrives in the evaporating apparatus under a pressure of 70 atm., expands in a receptacle and the cold produced by the evaporation is precipitated in the form of snow, which is retained by the filter, whilst the gaseous part, which is very cold, passes between the two walls and from the bottom of the apparatus is directed towards the suction pump of the compressor.

The snow is collected and compressed into blocks weighing about 17-18 kg. and sawn up.

**Industrial Applications of Cold**

Cold is used principally for making artificial ice, i.e., transparent ice from spring water or from pipe water supply, and crystal ice from distilled water. The evaporator of freezing machines is so arranged that a saline freezing solution surrounds the ice moulds, which are made of tinned iron or, better still, of galvanised iron, and are filled with water; the water solidifies in from twelve to eighteen hours and the blocks of ice are easily extracted from the moulds — which are of a slightly conical shape — after a short immersion in a bath of hot water to facilitate extraction. Installations for artificial ice are also used in skating rinks with systems of refrigerating
pipes containing a saline solution at —6° C. and —10° C., whilst the artificial tracks for luges and skis are prepared by mixtures of salt with or without refrigerating pipes.

The conservation of perishable food calls for cold to prevent the putrefaction of materials nourishing or otherwise, or, at any rate, to preserve their good appearance. The requisite chambers — whether warehouses for cold storage at ports supplied from refrigeration plants; or for cold storage at railway stations, or warehouses for transit, or for consumption, supplied from cold storage vans which are either refrigerated or kept at an equal temperature — are generally cooled by making freezing solutions circulate in closed pipes or more rarely in open channels in the places to be cooled. Various temperatures are used depending on the substances to be preserved: —12° to 10° C. for freezing fish; —10° to 6° C. for freezing meat; —8° to 3° C. for raw tobacco; —6° to 4° C. for preserving eggs, and preserving meat. Mention should also be made of refrigerators used for freezing eggs, and refrigerators at abattoirs for the preparation either of chilled meat, or of frozen or solidified meat.

Cold is also used for cooling large masses of water as electric generators, or various workplaces, such as explosives magazines on warships, which should not rise above 25° C.; food stores on merchant ships; cooling ships during voyages in hot climates, e.g. the Red Sea; theatres and cinemas; hospital warehouses, especially for chest cases and mortuaries, for which a temperature of —4° to 0° C. is sufficient, unless the requirements for autopsies necessitate freezing the bodies at —20° to —15° C.

In the chemical industry, cold is used industrially for numerous cooling operations, such as drying, extracting and freezing. For instance it is used to regulate the process of fermentation or other biological processes in breweries, yeast factories, bakeries, malt-houses; for the rapid cooling of wort in breweries; for cooling milk and cream in dairies; for granulating and washing crude margarine; for effecting better desugaring of molasses in sugar refineries; for some distilling operations, notably for that of distilling alcohol at a low temperature which gives greater purity to the product and greater simplification in the separation of empyreumatic oils. It is also used for cooling dye solutions, ensuring greater fixity of the colours; for cooling solutions used for mercerising and neutralising threads used in spinning.

The extraction of certain products is effected by cold in industries concerned with paraffin oil, lithopone and sulphur dioxide, and such other operations of the chemical industry as the separation of Glauber's salt and the salts of ammoniacal soda from the mother solutions, and the recovery of used acetones, ether, benzine and alcohol. The liquefaction of chlorine is simplified by intense cooling, as is also that of ammonia, carbon dioxide, air and rare gases; and with the extraction of helium from natural gases.

A kind of extraction by cold is done by drying certain products, for example, in the course of solidifying oils, in order to dry the hydrogen used for hardening oils; in blast furnaces for cooling; before the sintering of the coke; in glaziers' workshops, for brightening glazes, and in the preparation of pigments.

Substances are solidified by cold in numerous instances: in the manufacture of margarine, gelatine and glue; in the last case cooling makes it possible to reduce the period of drying from some weeks to twelve hours. In the manufacture of extracts from flowers by means of oil and alcohol, the oil is separated into clots by coagulating, while the alcohol is drained off with the extract.

In rubber and cable works cold is used to harden the pieces and slabs of rubber, since they can then be more easily worked and cut. In the manufacture of photographic plates and paper, the emulsion is solidified and dried. In films, the supporting material, i.e. on paper, plates or films. In making champagne, particles of lees which are deposited at the neck of the bottle are solidified by cooling the neck of the bottle intensely in a solution of glycerine for this way they can be removed without any loss of the wine.

An important application of cold for solidifying large masses is its use in the mining industry when sinking shafts, in order to fix shifting earth or moving and wet sand during the period of hooping until the shaft has been hooped or walled round. The freezing is effected by a concentric system of freezing pipes introduced into the shaft of the mine and kept advancing with the sinking.

Cold is also used in technical and scientific researches, when testing building materials and materials with regard to their resistance to very low temperatures or to sudden changes of temperature, and to determine the germinating power of seeds, the power
of growth of plants, and the vitality of parasite plants.

**Sources of Risk**

The occupational hazards for workers in the cold industry are very limited.

Exposure to low temperatures is the chief danger. But, as in the case of workers in the open air, cold is only important as a danger when the work carried out in freezing chambers is accompanied by heating the body through great exertion, such as por-terage in cold storage premises, or when there is frequent change from heat to cold, as in brewery work, in certain chemical works, and in small refrigerating works where the same person supervises simultaneously the steam engine, the dynamo and the refrigerating plant. The same holds good for ice factories where work requiring exertion, such as emptying moulds and discharging blocks of ice, is carried on at a low temperature — when such operations are not effected mechanically.

The injurious influence of cold increases with dampness of the air, which cannot always be avoided in the manufacture of ice; this matter must also be taken into account in other establishments which use cold. Moreover, cold and damp together exert an influence which is more injurious in proportion to any suddenness in the change of temperature, and to the skin being in a damp state or secreting sweat freely, in consequence of hard work at the same time or previously.

A second source of danger is represented by risks from escapes of gas from refrigerating machines, which present a danger varying according to the different products employed as freezing agents, whether ammonia, carbon dioxide, sulphur dioxide, or chlorides of ethyl, methyl, ethane or propane. These products constitute sources of poisoning for the personnel and dangerous contaminations for certain preserved materials; these troubles are all the more serious in that the chemical products are used under pressure which in ammonia machines reaches 9 atm., in sulphur dioxide machines 3.5 atm. and in carbon dioxide machines 50 to 60 atm. It follows that the smallest leaks give off quite an appreciable quantity of noxious vapours; and enormous quantities escape during serious accidents from the bursting of compressors or pipes. (See also article "Methyl Chloride").

There must not be overlooked the risks of explosions from excessive pressures, with ignition of explosive and combustible fumes at the moment of their escape. It should be borne in mind also that mineral oils, used for lubricating the compressors, may be transformed into hydrocarbons at the temperatures which are reached in running the engines; in that case they constitute inflammable and explosive mixtures.

In this connection the part played by static electricity, developed during the running of the engines, must be taken into account.

**Statistics**

It may be said that there do not exist any real statistics of occupational sickness and mortality relating to workers in the cold storage industry and in the manufacture of refrigerating plant.

In Great Britain the annual report of the Chief Factory Inspector for the period 1920-1922 mentions 7 cases of poisoning, one of which was fatal, in the industry of refrigerating by ammonia, as well as 6 cases of slight poisoning in a confectionery works.

In Germany information collected by the trade union of brewers and masters shows each year a number of more or less serious accidents from toxic products, but without specifying the actual number.

**Pathology**

Chief among diseases caused by cold must be mentioned diseases of the respiratory organs, rheumatic inflammations of muscles and nerves, and a great liability to infections of the mucous membranes. According to the constitution and individual susceptibility, the effect of cold makes itself felt upon different parts of the body, and causes organic injuries either directly by chilling, whence arise disorders of nutrition, of the muscles, articulations or nerves, or indirectly in consequence of the effect of infectious micro-organisms, the virulence of which becomes increased, or rather the resistance to which becomes lessened.

Among those working in the cold producing industry cases of necrosis of the limbs or parts of the limbs are rarely observed, in consequence of a more or less lasting retarding of the circulation. At the most there have quite rarely been observed cases of frostbite during work at very low temperatures, with liquid air for example, or of pruritus of the skin, and chilblains during prolonged repair work on very cold parts of engines or on refrigerating pipes. Among workers in refrigerating cham-
As regards general affections due to cold the reader is referred to the article "Air: Hot and Humid"

The injuries which arise from toxic products are more serious. While reference to various articles dealing with the products in question is indicated, certain points in particular may be noted here.

Ammonia escaping in a jet from a leak may cause burns, with the formation of blisters, due to the fatty protective layer of the skin being dissolved and the great affinity of ammonia for water. In the same way there may occur lachrymation, conjunctivitis, and, under certain conditions, keratitis. A strength of 0.15 per cent. of ammonia in the air causes definite irritation of the mucous membranes; and a greater strength, spasms of coughing with mucus expectoration which is thick and sometimes bloodstained, vomiting, psychic excitement and cramps which may have serious consequences. If the patient falls to the ground, that is if he falls into the zone of greatest concentration of carbon dioxide. It is, as a matter of fact, well known that, in consequence of its high specific gravity, carbon dioxide accumulates in the low parts of any place. As it is odourless, camphor is sometimes mixed with it when it is used in refrigerating machines, so that the smell may act as a warning.

The other freezing agents mentioned above, and less often used, have, in addition to similar effects on the mucous membranes, a narcotic action. The special effect of chlorine on the central nervous system should also be mentioned.

For methyl chloride, see that article.

**HYGIENE**

The best prophylaxis lies in the construction, fitting and correct installation of freezing machines. Such machines should not be placed in cellars if they are worked with heavy gases; and all communication between the engine-room and the upper floors of work-places, in the case of ammonia machines, should be avoided. Whenever possible two exits, opposite one another, should be provided, leading directly to the open air. Adequate ventilation should be provided and arranged so as to act at the floor level; the installation should be such that it can be controlled from a non-dangerous situation, outside the engine-room.

The material used in the construction of all parts of machines and pipes which work under pressure must be of irreproachable quality, the joints carefully made and the solderings perfect. Packings and screwed joints should be avoided. The suction and compression sides of compressors and pumps should be provided with the necessary manometers, as well as the oil separators of ammonia compressing machines. Taps and safety valves must be fixed at special points with adequate devices for evacuating the products in case of necessity.

During the working of the machines all indications of pressure and heating must be carefully watched, more particularly in the case of the compressor. Too much heat destroys the joints and the leather washers of carbon dioxide machines, or leads to the decomposition of ammonia with the formation of explosive gas. Work with a naked light must be forbidden in the vicinity of hot compressors; and it is still more important not to hunt for leaks with a light in the interior of a compressor which has been taken to pieces, nor in the pipes, or joints of the pipes. Leaks can be detected in ammonia installations by introducing into the pipes, or by spraying on to them, a solution of weak hydrochloric acid, which, in the case of a leak, leads to the formation of white fumes of ammonium chloride which are easily seen. With sulphur dioxide machines a weak solution of ammonia is used in the same way; and with carbon dioxide machines a solution of soap.

In other cases certain measures can be taken, e.g. the addition of ethyl bromide to ethyl chloride to make it non-inflammable.

Among measures of personal hygiene, the wearing of suitable working clothes which protect the worker against the rapid changes of temperature in the different places of work is of the greatest importance. Protection against humidity must be provided by wearing leather aprons, with the addition, when carrying ice, of coverings for the neck,
and gloves. During the repair of machines or pipes which are not tightly sealed, the possibility of a sudden escape of ammonia or sulphur dioxide must be borne in mind; and for this reason protective goggles and leather gloves which leave the ends of the fingers free must be provided for the personnel. The use of gas masks with absorbent charges giving efficient protection against the different gases should be provided for in case of escape of toxic products. It should be noted that gas masks can only be used when the strength of the escaped gases does not exceed a certain degree, which varies according to their nature, so that in any case a sufficient quantity of oxygen remains for respiration. Care must also be taken that masks fit well to the face and shape of the head of those who may have to wear them. Otherwise these masks will not be airtight, and they will expose their wearers to danger from penetration of the gases into the respiratory passages, and in consequence to poisoning.

In case of the escape of large quantities of toxic products, due to bursting of the machines or pipes, gas masks, which in several instances have proved unsatisfactory, should not be used. In the case of an explosion of an ammonia compressor, an attempt to penetrate into the place where the accident occurred showed that the gases penetrated through the clothing and the fabric material of the masks, causing pruritus and intense lachrymation, the absorption charges of the masks being rendered useless in a few seconds.

Oxygen respiratory helmets should be available for use, or outside air should be brought by a pipe, taking care that there are no leaks. It is still better to use respiratory helmets to which it is possible to send, from an unexposed situation, fresh air under pressure, which prevents the eventual penetration of toxic products to their interior, as well as atomised water. The wearing of wet macintosh garments is also advisable. The roping of workers who enter workplaces filled with poisonous gas should be absolutely compulsory.

The safety of workers requires that they should have sound knowledge of the use of refrigerating machines, of their working and repair work, and of how to act in case of breakdowns and accidents.

**Legislation**

Special measures for the transport of liquid and solidified gases, which should be kept in small stores and in small quantities, are laid down by the Prussian Ordinance of 2 August 1914. Similar Ordinances have been laid down in the other German States and in other countries.

It is desirable to mention that in Germany, subsection 23 of section 5 of the measures of protection laid down by the Trade Union of Malsters and Brewers makes it compulsory to provide for the workmen apparatus protective against toxic gases.

In Uruguay, the Decree of 27 January 1927, which regulates the conditions of work in the refrigerating industry, lays down the following provisions amongst others: the exclusion of persons under twenty years and over forty-five; half-yearly medical examination; the exclusion of persons who have been ill till they are in perfect health again; eight hours' work a day, with fifteen minutes' rest each hour or spells of three-quarters of an hour of work; the provision for workers of working clothes which assure good protection against cold; the air of refrigerating chambers must not be damp; means must be provided for ensuring dryness of the air; hot baths must be provided for the workers to be taken at the end of the day's work.

**Bibliography**


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**Rice-Field Workers**


**Technical Data**

Rice (*Oryza sativa*) is an annual graminaceous plant cultivated on a large scale in southern and eastern Asia (China, Japan, Indo-China, India, etc.), in certain parts of Africa (Egypt, Madagascar, etc.), in North America (Georgia, Louisiana, Arkansas, etc.), in Central America, in certain regions of South America in southern Europe (Italy, Spain, etc.).

This cereal, which represents the fundamental foodstuff of about 600 million human beings, grows in submerged areas. It is usually cultivated in permanent rice fields, though in Italy and Java, for instance, it is a rotation crop. The permanent rice field is that in which the rice undergoes uninterrupted cultivation on the same spot, especially in marshy fields, which are flooded during the growing season, and drained before the next crop is planted.
regions or those subject to frequent inundation, but lacking sufficient drainage for dry cultivation. In rotation areas the cultivation of rice alternates in a periodic and more or less regular manner with other forms of dry cultivation.

The cultivation of rice begins in winter. After the usual ploughing and preparation of the ground, small dykes are constructed which serve to keep back the water and to divide the field into small plots more or less extensive in size, according to the inclination of the ground and the necessity for subdivision. Sowing, which may be effected by hand or machinery, takes place towards the end of March or the middle of April. The ground must then be covered with a layer of almost stagnant water 5 to 10 cm. in depth.

In order to facilitate the taking root of the plants, which must grow to about 8 cm., drainage has to be resorted to, sometimes repeatedly when the plantation is threatened by the presence of aquatic animals and vegetation. Such drainage also affects destruction of certain parasitic plants, though certain others develop in a manner which necessitates weeding of the field. In the cultivation of rice, weeding, on account of its mode of execution, represents the most unhealthy phase of the work and must be regarded as the operation which involves the greatest risk for the workers' health. Other phases of cultivation — such as the preparing of the ground, sowing, harvesting, beating, drying on a threshing floor in the sun or in driers — demand effort which differs but little from that common to all agricultural work. Eight days before the harvest the rice field is drained. Certain aquatic animals die in consequence, and the decomposition of these leads to putrescent emanations.

The weeding of the rice is effected when the plant has reached a certain height. It consists in pulling up all the weeds and leaving the cereal intact. This operation takes place two, or even three, times yearly, and occurs between the second half of May and the middle of June, thus occupying a space of time of about forty to fifty days. In view of the relatively limited time during which this work has to be accomplished, recourse is generally had to the employment of a very large number of workers coming from the neighbourhood, or even from distant parts of the country, who are lodged in overcrowded dormitories in farms (in Italian: cascinali), from which they leave in the morning for the rice fields. These workers are usually women, young persons or children of both sexes who are obliged to enter the water which, at the time in question, reaches a height of 20-25 cm. They work with bare feet in a very short coat and cap, in a single line and in serried ranks like soldiers. This operation involves a highly uncomfortable posture bent forward with lowered head, legs far apart, the longer leg advanced and supporting the left forearm, and with the trunk turned in such a way that the left shoulder is lowered. Occasionally the workers vary this attitude, working with the left hand and supporting the right forearm on the right leg or, again, by keeping the legs together and bending the back further. Constant attention is required in order to distinguish the weeds from the plant. The former are pulled out by hand and thrown with the other hand in heaps on the ground or on the borders of the rice field. At the beginning of the daily work of weeding the temperature is relatively cold, whilst towards the end of the day it is extremely hot, the water reaching a temperature of 18-36°C. The duration of work in several countries is eight hours, broken by a rest period of two and a half hours.

It is in consequence possible to record as characteristic disadvantages of the work the following conditions:

1. work with feet and hands submerged in stagnant or almost stagnant water of depth 20-25 cm. and at a temperature of 18-36°C.;
2. work in an uncomfortable position involving flexion of the body on the hips;
3. work in soft, muddy ground, putrefied by the decomposition of manure and uprooted weeds.

Preparation of rice involves three types of operation: preparation of the "paddy", husking and polishing.

Rice in the "paddy" separated from the ear by beating is placed in vats in contact with water at 33-47°C. According to the climate, for a period of about thirty hours. The water is drawn off and steam caused to pass through the rice for between ten and fifteen minutes. The rice is thereafter dried in a thin layer on flat threshing floors for about two days. Hot-air driers are sometimes used or, again, the rice may be set in motion mechanically.

Drying swells and detaches the husk, which adheres very firmly to the grain in fresh rice and hardens the latter. In this manner the peripheral layers, which are very rich in phosphoric acid and B vitamins, are not broken during husking and not easily detached in course of polishing.

Husking of rice is done either by hand by primitive methods or mechanically by means of perfected machinery. In the first instance the "paddy" is struck by heavy hammers or pestles of wood with iron hoops, in a hard, wooden or earthenware mortar, or by means of stamping mills which crush the "paddy", which is placed in a hollow depression formed of dry clay. These processes, which provide a mixture of husked rice, "paddy", and unhusked rice (later separated by winnowing), are inadequate for the treatment of large quantities of grain intended for export. Mechanical husking implies the following operations: previous passage of

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the "paddy" through a cleaning and separating machine, including ventilators and sifting screens; passage through a husking machine (composed of two concentric discs, one fixed and the other moving on a vertical axis) which detaches the exterior husk, which is then removed by winnowing in a second separator. The mixture of husked grains and others which are not husked then undergoes sorting in a third separator, which returns the unhusked grain to the husking machine, leaving the husked rice which constitutes the so-called "cargo rice." The latter then undergoes treatment which transforms it into polished rice.

Polishing is effected by machines arranged in cascade fashion, and consisting essentially of a solid cone turning at high speed around a vertical axis inside a fixed hollow cone of almost similar conical form. The grains pass between these two cones where they lose the seed and the progressively as the end of the weeding operations is approached. This increase was attributed by Ganora to diminished organic resistance as the work advances, which he found to be directly connected with the age (too young or too old) of the workers, the excessively long working hours, the lack of measures of protection (sleeping accommodation, feeding arrangements, etc.). In countries where measures are actually in force, the majority of occupational hazards which formerly menaced workers in the rice fields have greatly diminished.

Continual immersion of the feet and hands in water has in the end a very detrimental influence on the tegument. The water chiefly exerts an effect consisting in diminishing the fat in the tissues and consequently causing dryness of the skin. The epidermis is macerated and the capacity of resistance to small traumatisms caused by hard plants is therefore diminished. Wounds and rhagades ensue, often complicated by local inflammation (whitlows, phlegmons, circumscribed abscesses) caused by the aquatic flora rich in microbes. These infections find in the skin, deprived of its natural means of defence, a medium favourable to their development. There have in consequence occurred cases of septicemia and cases of tetanus.

At the commencement of the weeding period — the second fortnight in May — when the water in the rice fields is at rather a low temperature, there may be noted on the hands and feet of the workers vasomotor symptoms,

![Fig. 100. — Preparation of the rice-field (by means of the "Spianone").](image-url)
accompanied by a sensation of cold, heaviness and even paresthesia. The fingers become pale, the skin of the hands and fingers, especially of the thumb and first finger, becomes opaque and has a paralysed feeling. This sensation is followed after some hours by a sensation of heat and the parts affected become red and almost cyanotic. This syndrome, which in general recalls somewhat Raynaud's disease, is due to the effect of the cold water on the sensitive nerves of the skin. On the other hand, towards the end of the weeding period the work in very hot water finally renders the skin of the lower limbs — feet and legs — red and oedematous. There is maceration of the skin with painful rhagades, due largely to hyperaemia in consequence of lowering of the tone of the vascular system and of the tissues.

Formation of occupational callosities is of frequent occurrence. The women workers, who plunge their right hands into the water in order to seize and uproot the weeds, show on the cubital border of the hand wearing of the skin, which later not infrequently develops into erythema, intertrigo, broken skin and painful suppuration, which is relatively persistent. Later on, the epidermis becomes hypertrophied and gives rise to a true callosity, frequently developing fissures and rhagades.

Mantegazza (1909) has described under the name of "rice workers' dermatitis" the cutaneous affection which often suddenly attacks simultaneously whole shifts of workers at the very beginning of the season without distinction of age, constitution, sex, cutaneous resistance, etc. The affection is localized on the parts of the body in contact with the water and attacks particularly the ankles, toes and interdigital spaces, the lower third of the legs, and the hands.

In general, the leg most affected is that which is advanced in order to open a way between the stalks of rice and the weeds, whilst the other leg, which is behind on ground freed from weeds, often remains almost immune. The hand most affected is that which enters the water to uproot the weeds — the right hand in right-handed individuals and the left in left-handed, or both hands in the case of ambidextrous persons. The symptoms consist in intense irritation, sensation of heat and tension, more pronounced and disagreeable when the workers have left the water. At times the pain is so violent that it interferes with rest and sleep. The symptoms at first consist in erythema with large irregular patches which are slightly raised and oedematous. The local temperature is high; these patches are followed by the appearance of papulae about the size of a lentil or a pea with indefinite edges, a smooth, tense, shiny and elastic surface, and vivid red in colour. Occasionally the symptoms are arrested at this point or there may be a relapse. More frequently, small vesicles and phlyctenules the size of the head of a pin are formed which recall eczematous forms of dermatitis. The
content of these vesicules readily becomes turgid with formation of pus. The vesicules are always superficial, epidermic or sub-epidermic, and break easily, leaving erosions of variable size in accordance with the extent of the inflammatory process. In certain cases the more deeply seated parts of the skin are attacked by an inflammatory oedematosus infiltration.

In general, the lesion heals rapidly, more especially when it is arrested at the stage of erythema or papulae, and it does not progress when work in the rice fields is interrupted. In such cases improvement takes place twenty-four hours later. The subjective symp-

toms disappear after a short spell. The lesion sometimes leaves small scars and slight regularly disseminated pigmentation.

As regards the etiology of this disease form, which Mantegazza considers a true dermatitis and not an eczema, several hypotheses have been put forward. Leaving aside the hypothesis implicating the effect of excreta of ducks, geese or other animals suffering from certain epizootic affections or that of chemical manures and acidity of the ground, the attention of doctors has been directed to the possibility of the pathogenic action of certain plants. This hypothesis has been advanced in consequence of the observation that the parts affected are those in direct contact with the weeds. Various plants other than the rice plant have been said to be responsible, but Mantegazza is of the opinion that this form of dermatitis is due to the action of naiadaceae (Naia, minor and major), which are provided with leaves having their edges covered with conical needles, flat and adhering to the rest of the leaf, the free part of which terminates in a very fine point likely to prick the skin. To the mechanical action of these needles is added the effect of scratching by the victims and the further action of pathogenic germs living in the water. Wollbach and Todd have remarked the occurrence in Gambia, more frequently amongst women and children than amongst men, of chronic ulceration of the legs. The action of the water favours the outbreak on the unprotected skin of the legs of swellings and lesions resulting from small wounds which become very readily infected. Malaria would appear to find in the rice fields an important medium of diffusion. The irrigation waters offer favourable media to the development of the anopheles and the generative cycle is accomplished usually between thirty and sixty days, with the result that the period from May to September offers the possibility of the develop-

Fig. 192. — Attitude of a woman worker when weeding the field (according to Peracchi).
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The frequent presence of these does not, however, always appear to correspond to a frequent incidence of cases of malaria, especially in those regions where improved sanitary and social conditions have been introduced (Giardina, Novelli, Alessandrini, Sampietro, Hermès, Kamp, Bentley, Kendrick, Nocht, etc.). Similar factors have also been observed in Argentina by Mazza and Rickard (1930).

In order that the anopheles should cause malaria, it has to become infected, that is to say, it must bite a person suffering from malaria and introduce into its blood sporozoites in the stage of gametes. The rice fields are submerged from the middle of April and, supposing that the female anopheles lays its eggs immediately after submersion, there would hardly be time for complete development of the insect during the weeding period, that is to say, towards the middle of May. At this moment a mosquito is in the larval stage or at most at the nymph stage; the insect reaches full development later when the workers have already quitted the rice fields and the anopheles thereafter rarely has an opportunity of becoming infected. Further, the operation of weeding disturbs the surface of the water which is apt to cause submersion of the majority of the nymphs and their destruction. The number of mosquitoes becomes considerable in July only and they can only be said to be abundant during the month of August, but the possibility of malarial infection by the anopheles is restricted since contact with man is rare.

It may be said in consequence that workers engaged in weeding are but rarely exposed to malaria (Preti). The same is true of the harvest workers, the harvest taking place between the second fortnight of September and the second fortnight of October, a time at which risk from contagion is not so great as might be supposed, more especially since the harvest work commences at an hour when the sun is already up and ceases before sunset. On this account, the possibility of mosquito bites is reduced in view of the nocturnal habits of these insects. It is further necessary to take into consideration that at this time of the year bad weather and cold nights considerably reduce the number of mosquitoes. Thus, malaria in the regions under rice cultivation can hardly be regarded as an occupational disease of the rice fields, but more accurately as a disease connected with habitation, the most important risk of contagion existing in the farms and stables which, in Italy especially, are the chosen spots for the development of mosquitoes. It is in these places that the majority of these mosquitoes bite their human victims, become infected and capable, in consequence, of transmitting infection. In regions where the farms are situated near or on the rice
fields, the development of the anopheles mosquito finds in the rice fields two essential conditions: a place of incubation (the rice field) and food (stables and habitations acting as the place of infection).

Chills also constitute an important cause of the injuries to health encountered: inflammation of the respiratory passages (rhinitis, bronchitis, pneumonia, etc.) or of the serous membranes (pleurisy, arthritis), of muscular or nervous affections (myositis, nephritides, etc.), the latter being connected with the vascular state of the skin.

In certain regions there have been noted manifestations of acute gastro-enteritis accompanied by lack of appetite, abdominal pain and diarrhoea, with high temperature, etc. These troubles are generally unimportant, sporadic, and possibly due to the absorption of impure water.

Other important affections are those relating to the working posture. Work in the rice fields does not demand excessive muscular effort. Of relatively short duration (forty to fifty days), it is eminently seasonal work. Nevertheless, it may, especially during the first days of work, give rise to fairly important symptoms of fatigue, particularly since at this moment the system has not had time to become adapted to the work. This fatigue often manifests itself in the outbreak of acute symptoms resembling those which precede an infectious disease, the worker suddenly becomes the victim of slight or violent shivering, the temperature rises to from 35° to 45° C. and remains at that figure for one or several days, falling thereafter with abundant sweating and without any further complications. During the period of fever, there is pain in the lumbar region and in the limbs, accompanied by headache and intense thirst. This state of fatigue seems to be due to the fact that the work causes repeated contraction of the same group of muscles (Preti). Though protected from the sun by wide-brimmed straw hats, the women workers work in a bent position and are sometimes attacked by sunstroke (before thunderstorms) under the action of the summer sun, augmented by reflection from the water.

The working posture which the woman worker is obliged to maintain may, according to certain authorities, cause deviation of the vertical column (cyphosis, lordosis) and pelvic deformity, especially in the case of young persons. This latter condition Preti has, however, not observed. It is probable that the limited duration of the work and the daily rest period attenuate to a large extent the effect which such an anti-physiological attitude might have on the bone structure.

The bent position, submersion of the feet in water, may give rise to complications in regard to menstruation, rendering it painful and abundant. Further, it has been noted that during pregnancy, troubles manifested by violent contraction of the uterine muscle fibre and by premature haemorrhages, and finally by miscarriage or premature or sudden delivery, occur. The contraction exercised during hours of work on the abdominal organs may involve alterations of the said organs and of the blood vessels, which finally lead to gastro-intestinal atony, dysuria and pre-malleolar oedema.

Lesions of the cornea, resulting from wounds due to the point of the spikelets on the rice during the harvest season have been reported by Gherardi (1921). In 10 per cent. of the cases, there was loss of sight, in 43 per cent. a more or less important diminution of sight. Forms of blepharitis and conjunctivitis due to exposure to the sun are frequent (reflection from the water).

No special data are available relative to the pathology of workers in the rice fields in China, Japan or Indo-China. In regard to those of Brazil, it is merely known that a considerable number of fatal cases due to serpent (asp) bites have been reported.

In regard to the pathology of workers engaged in the handling of rice, Bron, as early as 1860, has described cases of erythema of the face amongst workers engaged in unloading sacks of rice. This dermatitis was attributed to the action of a parasite in the rice. A similar epidemic was reported as having occurred at Le Havre in 1919, by Loir and Legagneur.

In 1921, Hodara investigated in Constantinople an epidemic characterised by an eruption with violent shivering, which broke out amongst dockers. The disease had an incubation period of one to two days, a duration of three to seven days, and even fifteen days. The cutaneous symptoms were localised on the face, hands, neck, forearms and back (shoulders).

Michelson, who also studied this affection (1921), speaks of two types of irritation: anaphylactic syndrome due to dust inhalation and mechanical action on the skin. Others are inclined to attribute it to parasites, and in particular to the "pediculoides vermiculosis".

Alderson and Rawlins (1925), under the designation "rice poisoning", have described a form of dermatitis which
they met with in California: erythema, with purulent folliculitis, and diffuse eczema, with secondary infection and irritation. These cutaneous troubles were localized on the hands, on the flexed side of the wrist, on the neck and on the chest. Etiology was very hard to establish. The authors admitted the presence of special susceptibility to the proteins of rice, for they did not meet with cases of dermatitis in the "polishing" department of the factory, but merely amongst those workers who handled the rice prior to cleaning ("paddy"). It is true that the authors did not effect cutaneous tests, but they likewise did not discover the presence of parasites in the rice. There occurred to them the possibility of attributing the symptoms to the action of the silica present in the "paddy". On the other hand, it must be admitted that such affections are, at least in part, due to such factors as a distinctly detrimental absence of cleanliness on the part of the workers and to the presence of traces of manure amongst the rice.

In the case reported by Van Geldern, the impetigo met with was accompanied by asthma (anaphylactic!).

A case of acariasis due to rice was reported in Italy (1927) by Ferrero. The disease was characterised at the outset by an erythematous-papular eruption, and eventually by the formation of vesicles and pustules. The patient suffered at the same time from attacks of coryza and very serious loss of weight. A parasitological examination of the plants has revealed the presence of numerous acari of the Pediculoides ventricosus family.

The rice dust exercises an action similar to that of other cereals (corn, wheat, etc.); it irritates the mucous membranes and especially the conjunctival mucous.

In factories in which rice is handled, there is also a possibility of explosions followed by outbreak of fire due to rice dust (see article "Dusts").

Hygiene

As regards the technique of work on the rice fields, there has for some time back been adopted a new system involving the transplanting of the rice. The rice is sown in a plot of ground in closely planted rows, and when the plants have attained a certain height the workers uproot them and transport them to the rice fields. This system does away with weeding, but the operations which replace it involve the same disadvantages as those encountered in weeding. The one advantage consists perhaps in the fact that it enables the submersion of the rice fields to occur one month earlier, which from the point of view of the development of the anopheles mosquito is of no great importance, since the production of mosquitoes does not occur during the first months of work on the rice fields.

Mechanical weeding is becoming extensively applied, but it does not eliminate entirely weeding by hand, though it reduces it to a great extent. Besides, from the hygienic and technical points of view represents a real progress.

In order to reduce the number of anopheles mosquitoes, the breeding of fish which are natural enemies to the larvae and nymphs of the mosquitoes, has been applied on the rice fields. The kinds of fish which give the best results are voracious varieties, such as carp. An indirect result of this method is that of obtaining, towards the end of the season of the rice fields, an excellent food product. The field anopheles mosquito is insensitive up to the moment at which it becomes infected. Such infection is, as has been seen, very rare on the rice fields. On the other hand, the most dangerous mosquitoes are those which surround the workers in their habitations. It is possible to exclude the penetration of the anopheles mosquito by the adoption of simple mosquito netting. Taking into consideration the short distances which the anopheles varieties fly, legislative provision has been adopted in Italy tending to impose on the provincial councils a fixed minimum distance between the temporary habitations of the workers and the rice fields.

With regard to measures for the protection of workers, it is necessary to take into consideration especially the living conditions and the type of work employed, the labour being supplied, as has been seen, by large drafts of immigrants. It is possible, under these circumstances, to understand the importance to be attached to the temporary habitations constructed for these workers; cabins for meals and quarters for the night; installation and maintenance of habitations and dormitories in accordance with the principles of hygiene; segregation of the sexes; requisite cubic air-space; ventilation; provision of drinking water; good feeding arrangements; medical supervision; prevention of malaria; detection of malaria cases constituting a danger on account of the dissemination of malaria, as well as detection of other social scourges; syphilis, open tuberculosis, contagious skin diseases, etc.; vaccination against smallpox, etc.; reduction of working hours, which
should be interrupted by adequate rest periods, etc. The work should not commence until after the sun has risen and should be stopped a few hours before sunset, with a view to preventing mosquito bites.

For the prevention of dermatitis, the wearing of simply made cloth leggings is to be recommended. It is also advisable to apply to the skin a protective oil or some greasy substance. Deformation of the bone structure due to bad posture should be prevented by excluding from work on the rice fields young persons, and particularly those under fourteen years of age.

Pregnant women should be excluded from work from the seventh month until fourteen days after birth. It must be admitted that in almost every case pregnant women refrain from engaging in work of this kind in the more civilised countries.

**Legislation**

Very detailed legislation relative to work in the rice fields exists in Italy. General regulations for the application of legal measures relative to the cultivation of rice (Part IV, Consolidated Text, Health Laws of 1 August 1907, No. 636); instructions for ensuring the provision of drinking water to workers engaged in the rice fields (Royal Decree of 29 March 1908, No. 157). There must likewise be taken into account measures concerning housing, provision of drinking water, prophylaxis in regard to disease, dormitories, etc., in Part III of the Regulation on industrial hygiene (14 April 1927), which deals with hygiene in agricultural undertakings. The most important points covered by Italian law are the following:

1. Determination of minimal distances between the rice fields and the workers' homes; running off and discharging of water from the rice fields;
2. Obligation on the part of the employers to provide adequate and free medical and pharmaceutical treatment;
3. Obligation to furnish immigrants with dormitories and hygienic housing, well aired and ventilated and with provision for segregation of the sexes;
4. Obligation to provide on each farm a room, the apertures of which are provided with mosquito nets, to accommodate workers suffering from malaria;
5. Exclusion from the work of children under fourteen, and pregnant women in the last month preceding birth and for a period of thirty days after birth;
6. Prohibition against commencement of work on the rice fields prior to sunrise, etc.

In Spain, the Royal Decree of 27 January 1924 lays down certain rules calculated to prevent malaria caused by work on the rice fields in the valley of Bas-Llobregat.

Data relative to health and sanitation laws in other countries engaged in the production of rice are not available.

For compensation of occupational injuries amongst rice workers, see articles "Occupational Diseases: Definition and Compensation" and "Malaria".

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(Parma.)

**Röntgen Ray Operators**

(Occupational Pathology of)


**Sources of Risk**

The use of X-rays for diagnosis and therapy, the manufacture of the necessary tubes and bulbs for X-rays, and electrical apparatus expose the operator, his assistants, and any workman employed in this industry to a series of physical and chemical agents which may act injuriously on the system. The dangers can be summarised as follows: direct biological action of the Röntgen rays on the organs and human tissues from prolonged and repeated exposure; effect of the toxic
gases developed in the places where the high tension currents are produced and the X-ray tubes are employed; and finally lesions from the electric currents in individuals imprudently coming into contact with the generators or connecting wire of low or high tension.

Radiologists, therefore, are brought continually under the influence of the X-rays, especially when making radiographs which oblige them to approach the sources and particularly to expose their hands (when manipulating the stand diaphragms, touching the patient and turning him towards the screen) and their face (which is brought near to the fluorescent screen for careful study of the slight images thrown on to it).

The medical man and his assistants employed in the room are further exposed to the action of X-rays during radiography, and especially during the long treatments by radiotherapy requiring constant supervision of the apparatus and the patient.

The workman making the X-ray tubes is exposed to the action of the rays when creating the vacuum which is, at the same time, subjected to currents of high tension a highly delicate and rather long process during which the workman must unceasingly watch the tube and manipulate the vacuum pumps.

Röntgen rays are known to be electromagnetic vibrations of ether of very short wave length and consequently of high frequency — vibrations which are transmitted in a straight line from their source (represented by the anti-cathode of the tube or bulb) with a speed of 300,000 km. a second.

As it is a question of the central projection of divergent rays, X-rays obey the law of dispersion on a given surface decreasing with the square of the distance.

Röntgen rays have greater intensity the greater the reproductive activity, the longer the cariokynetic process has lasted, and the less the morphology and functions of the cells differ.

Whatever is the truth, there is no doubt that when X-rays are absorbed by human tissues they exercise an action which differs according to the type of the cellular elements attacked.

In other words, normal and pathological tissues have differing degrees of radio-sensitivity and there is a law which summarises admirably this differing sensiveness of the tissues. This law, laid down by Bergonie and Tru-baudet as soon as radiology came into existence, is still in accordance with the facts despite the quantity of new facts and observations made since it was enounced and sometimes even appearing to contradict it. It is as follows:

X-rays have greater intensity the greater the reproductive activity, the longer the cariokynetic process has lasted, and the less the morphology and functions of the cells differ.

In other words, the mammary gland, for example, is very much more sensitive to the rays during pregnancy than during functional repose, and the first spermatogenetic cells are more
sensitive than the spermatozoids, while differentiated unicellular organisms can be regarded as almost completely indifferent to X-rays.

According to the law of Bergonie and Tribaudieu, it can, therefore, be said that for normal tissues a scale of radio-sensitivity exists following the affecting organs and tissues in descending order: lymphatics, testicles, ovaries, skin, mucous membranes, renal and hepatic tissue, blood vessels, connective tissue, muscular, nervous, cartilagenous, and lastly, osseous tissues.

Therefore, though it be admitted that every cellular element in human tissue is susceptible to the injurious action of X-rays, it must also be admitted that, from the practical point of view, the changes most easily and readily seen in persons subjected to the prolonged effect of X-rays are those in the skin, the sexual glands and the blood-forming organs.

Gases are given off into the air when the current is passing through the tubes. These gases finally so impregnate the atmosphere as to give it a characteristic smell and produce irritation of the throat. They are nitrous fumes and ozone. Nitrous fumes are given off mostly at the points where the revolving commutators act or the current is excited by sparking. On the other hand, a high tension connection or a tube giving out X-rays produces ozone.

The injurious effect of these gases is so far only imperfectly known. They set up an irritating dry cough and cause a prickling sensation in the throat. Probably they have a slight toxic action causing frequent headache in those working in an atmosphere saturated by these gases.

Lastly, reference must be made to the dangers to which the radiologist and his assistants are exposed from the currents of high or low tension. They may cause painful muscular twitchings varying from a passing paralytic arrest of the heart's action, and thus death from electrocution.

The danger lies in the intensity of the current traversing the human body where it makes a short circuit between the wire and the earth. This danger bears relation to the voltage, the resistance of the body and the points of contact. If the person has on leather shoes and has dry hands, resistance may be very high (50,000 ohms) and contact with the electric wires involves no danger. But if the hands and the feet are wet, and the body temperature is high, well, etc., resistance may be down to a few hundred ohms, and death ensue with currents of 90-100 volts.

The fortunately low intensity of the current used in medical radiology with high potential explains why in general the consequences are not serious.

**Pathology**

Röntgen's discovery in 1895 was followed all too rapidly by quite a series of injuries from six to twenty-four months later among the personnel using X-rays.

The first to draw attention to the danger was the engineer O. Leppin in 1886, followed two weeks later by W. Markuse.

The lesions set up multiplied so rapidly that in 1907 Dean, of London, in his statistics of occupational dermatitis caused by X-rays, cited 30 cases which had occurred in Great Britain. According to Krause, up to 1911, 26 cases of carcinoma had been recognised as due to X-rays among members of the medical staff and among these of the technical staff manipulating the apparatus, and 4 among patients treated. Hesse, at the same date, cited 94 cases of carcinoma, and to-day the number of victims unfortunately amounts to hundreds, several of whom, practitioners of high eminence, have watched their malady, accompanied by intense suffering, advance to a fatal conclusion.

The cutaneous lesions of radiologists excited by X-rays rarely take on acute form, even after an exposure of short duration but strong intensity. On the other hand, a dystrophic radio-dermatitis develops which begins insidiously and goes on slowly, but with advance to a fatal conclusion. This dermatitis is provoked by the action continuously repeated during years of quite small doses of radiations. Generally, the cutaneous lesions are localised on the hands (especially the left hand), the face and the chest. The hands and fingers are most often attacked on their dorsal aspect. The thumb nearly always escapes. It is not uncommon for the lesion to be situated on the wrist or forearm when the person has been accustomed to work with bare arms. For purposes of description may be chosen chronic radio-dermatitis of the hands.

The first precursors of radio-dermatitis are circulatory in nature. The fingers become reddish violet, with a sensation of fullness and often of dryness; next, the skin, especially on the back of the fingers, becomes thickened and loses its elasciity. Sometimes the hair falls off and more frequently breaks.
From the first the nails assume a special appearance. Longitudinal striae appear; they often become fragile and break, falling off in pieces or as a whole, while the edges become hypertrophied and crack. Sometimes the nails atrophy to such an extent as to disappear. As time goes on, the skin changes always become more marked as the sebaceous and sweat glands atrophy and telangiectatic and hyperkeratotic areas especially appear. Often ulceration first appears when the horny patches become detached and it progresses without granulations and without any inclination to cicatrisation. The constantly increasing atrophy of the skin causes the fingers to become thin in characteristic fashion, and finishes by bringing about ankylosis.

But the worst sign is that of cancerous degeneration, which attacks the cutaneous ulcers by preference: the edges become infiltrated and thickened, while the bottom discharges, bleeds readily and becomes covered with crusts.

This form, after years of very slow development, takes on a different appearance determined by the occurrence of metastases affecting the adjacent glands and the spread of the cancerous process to the internal organs.

Such is the course that has been observed in dozens of radiologists and led, at first to progressive mutilation, and later, often enough to the death of many pioneers of radiology.

According to Hesse, tumours caused by X-rays are much more malignant than are ordinary tumours of the skin. Hesse gives a mortality rate for these cancers of 20 per cent., Goeneri (1909) of 24 per cent. among 33 cases recorded in medical literature; Porter (1907) and White describe 6 fatal cases even after surgical intervention; Porter in 1909 collected 36 cases of carcinoma, of which 34 were occupational.

Cole, as the result of an enquiry (in 1924) into cases of occupational radio-dermatitis, shows the number to be very high. From histological study of a certain number of cases, he concludes that sclerosis of the nutrient vessels of the skin is the true basis of the radiodermatitis; disappearance of the glandular elements of the chorion (the chorion being thickened by a hyaline degeneration), and the appearance of new vessels (telangiectasies) in the chorion. At first the epidermis is little altered; slowly there is noted an epithelial proliferation with epithelial projections passing downwards.

In 1917, a French radiologist noticed the appearance on the thumbs, index and middle fingers of both his hands of crusts looking like papillomata. For two or three years, by redoubling precautions, the lesions remained free from pain although tending to increase in

![Fig. 104. — Occupational dermatitis due to X-rays.](image)
size. The radiologist himself treated most of the lesions except one, which developed an epitheliomatous ulceration discharging and spreading. He then destroyed it by diathermy and in two months secured complete cicatrisation and a cure which lasted for several years. Some time afterwards, another radiologist who observed blackish crusts on his two hands, principally on the fingers, noticed that, even when keeping away from every source of X-rays, the state of his hands got rather worse and that an epithelioma developed on the right side of the lower lip. Application of diathermy to these epitheliomata (due to Röntgen rays) was followed by healing without recurrence in the four following years.

At the present time, certain fatalities with leucaemic symptoms seem to have occurred more frequently among radiologists than would have been expected on the average — so much so indeed and under such conditions as to suggest an etio-pathogenic relationship between the continuous action of X-rays and the maladies in question (see the article "Radium").

The action of X-rays on the red blood cells is not very marked; certain writers have observed transitory diminution accompanied by granular degeneration and polychromatophilia (especially after a long exposure). Blondi showed (1908) that X-rays affect the red blood cell formation in such a way as to produce the picture of aplastic anaemia. This fact has been confirmed by Cesaris Demel. The specific weight of the blood is increased as well as its coagulability; the globular resistance, on the other hand, is diminished.

It is on the leucocytes and the haematopoietic organs that X-rays exert their baleful action...

After a brief period of leucocytosis,
characterised by an increase of the neutrophil polymorphonuclears, a leucopenia ensues as a result of diminution in activity and the leucopoietic function. In strong doses X-rays cause a destruction of the haemopoietic organs, and on the other hand, in small doses a leucocytosis.

The leucopenia affects especially the lymphocytes (Linser and Heller). In radiologists the polymorphonuclear leucocytes are affected (Jagié, Schwarz, etc.), and in certain cases the acidophil leucocytes. Aubertin, on the other hand, has shown an increase of the neutrophils and eosinophils. Politzer has described swelling of the nucleus, and more especially of the chromatic granulations in the polymorphonuclear neutrophils analogous to those of phosphorism.

Aubertin, who examined the blood of sixteen radiologists who had worked for six to eleven years without trouble of any kind, described in 6 cases, mononucleosis from diminution of the polymorphonuclear neutrophils without hypoeosinophilia (but on the contrary an increase of eosinophils) and a total diminution in the number of leucocytes (4,000). In 10 cases slight polynucleosis with eosinophilia existed.

The leucopenia is intense (Jagié, Schwartz, etc.); it is said to be even proportional to the intensity of the exposure.

The lymphatic follicles of the spleen, thymus, intestine and, in general, all the lymphoid tissue of the organism become atrophied in a few days. The destruction of the cells of the lymphatic system takes place without a latent period and rapidly in a selective way. The alterations in the splenic pulp and bone marrow take place on the contrary when a cutaneous reaction has already appeared (Heineke). The polymorphonuclear neutrophils are the elements in the white corpuscles which resist the longest.

The anti-leucocytic action of the X-rays may be primary or secondary; it is said to be due to the formation of leucocytotoxic and leukolytic substances (Röntgenian toxin) on which depend the primary leucocytosis and the secondary leucopenia. The existence, however, of this toxin is very doubtful and is even denied by some authorities.

At an advanced stage a lymphoid or myeloid leukaemia has been described in the radiologists (in Vienna, Munich and America) thus affected, with characteristic modifications in the blood count (leucocytes reduced to 5,300 and 6,000; notable diminution of the polymorphonuclears and especially of the acidophilis, which were completely destroyed; increase in the lymphocytes; the number of the red blood cells remains normal).

Vaquéz (1911) records the case of a radiologist who died from myeloid leukaemia; Taber (1924) the case of the radiologist Mordenhoff who died in 1922 from aplastic anaemia.

Besides this type of leucopenia with lymphocytosis, Aubertin has described a second type among professional radiologists with neutrophil and eosinophil leucocytes.

According to Gavazzeni, the radiologists are said further to run the risk of an aplastic anaemia with fatal results. This form, due to X-rays as well as to radium and thorium, is the result of progressive destruction of the blood-forming centres after a long exposure (Aubertin and Bordet).

The disease affecting the bone marrow is also the cause of purpura. The giant cells are affected and the formation of blood plates is checked. To a lesion which at first is partial, there follows a complete lesion of the bone marrow.

Lesions analogous to those set up by X-rays are produced by radium (see article "Radium").

In 1921, Pfahler proposed at the meeting of the Philadelphia Röntgen Society that radiologists should make a study of their blood, and asked for the co-operation in this matter of all those in America. The following conclusion could be drawn as the result of his examinations:

Blood pressure is generally rather low in radiologists but is not accompanied by definite symptoms.

Complete examination of the blood of 142 persons employed in the X-ray laboratories of the medical bureau of veterans in the United States had not shown any noticeable modification of the morphology of the cellular elements in the blood, nor even an appreciable modification in their number except very exceptionally in a few isolated cases (Matz, 1925).

Weindrach, of Odessa (1926), from an examination of the blood of 21 persons employed in X-ray laboratories, stated that, in cases where harm had been caused, eosinophilia is a common phenomenon connected perhaps with changes going on in the spleen; that there was a diminution in the number of the red cells and a corresponding fall in the haemoglobin.
During these last years the researches of experts have multiplied with the object of making clear the alterations in the blood which could be regarded as the expression of an occupational pathology of the haematopoietic organs of radiologists. But the results are unfortunately too divergent to be able at the present moment to draw conclusions. The results of the enquiries by Bertoletti, of Turin, on the state of the blood of Italian radiologists may be cited.

Apart from a common anisocytosis and a slight hypochromemia a frequent drop in the number of blood cells and in the number of red blood cells has been observed. On the other hand, among several old radiologists there is an obvious tendency to excessive production of cell elements.

The principal characteristics in the white blood cells are, in the great majority of cases, a dominant leucopenia which shows itself rapidly in the first years of exposure and increases with time. This leucopenia is essentially set up by a diminution of neutrophil leucocytes, while the basophil tend to disappear: the picture of the acidophils is, on the contrary, very variable. There is a general tendency to increase of the lymphocytes, often the passage from a relative to an absolute lymphocytosis, especially among some old workers. A real increase of the mononuclears takes place. The leucopenia associated with the absolute lymphocytosis can almost produce an inversion of the leucocytic count.

The changes in the histo-chemical picture of the blood of radiologists comprise two fundamental phases.

In the first, the rays do not damage the haematopoietic centres, but only the circulation. In the second, a real lesion may take place marked by the appearance of certain primordial pro-lymphocytic and monocytic forms. Further, attention should be drawn to the fact that radiologists who manipulate radioactive substances show a very definite tendency to impoverishment of the blood with marked diminutions in the number of the red blood cells. Caffaratti (1922) from an examination of the blood of 50 Italian radiologists detected anisocytosis and an advanced and persistent form of leucopenia, with retrogression after exposure to the rays had ceased.

Of the effect of X-rays on the sexual glands, it can be said that, although undeniable, its importance has perhaps been exaggerated from the practical point of view. As a matter of fact, the women who work in X-ray rooms only exceptionally show any interference with their periods or sterility, and as for the men frequently to X-rays (doctors, attendants, workmen), their potential coendui always remains unaffected, and it is rare to find azoospermia with sterility. The enquiry made by Bertoletti on this point brings out the fact that many Italian radiologists, after a long and tiring career, have numerous and quite robust children. Naujoks (Berlin) has also made a study of the fertility of radiologists' assistants, and in an enquiry covering 91 women 12 were said to be sterile as a result of X-ray work, while 9 out of a total of 125 children were reported as suffering from derangements of development and nervous troubles more or less imputable to the action of X-rays.

Finally, a general kind of malaise is found which is characterised in an early stage by nausea, vertigo, dyspnoea, tachy or bradycardia, etc. The sensitised organism reacts, even to small doses by typical anaphylactic shock (bradycardia, leucopenia, inversion of the leucocytic formula) or by an inversion of the form (hyperleucocytosis, lymphopenia, tachycardia).

The asthenia at times observed can sometimes be attributed to fatigue and perhaps also to remaining long in a badly ventilated room and to insufficient rest.

These modifications, as well as those of the skin, cannot be said to be on the increase, and were observed chiefly amongst the early specialists who had not proper means of protection or among those who did not use them in a proper way.

**Hygiene**

Knowledge of the dangers caused by X-rays and of the conditions favouring their injurious action suggests a whole series of measures of protection which, if scrupulously observed, possess real efficacy in safeguarding the health of radiologists.

From the technical point of view, the introduction of the anti-cathode — so characteristic at the surface of oblique rays — made by Röntgen himself, represents, apart from tubes made for special purposes, the only improvement in the construction of X-ray tubes. Coolidge introduced the incandescent cathode as a source of electrons in place of the hollow cathode, and gave to the new tube the form in which it is now known.

But among the defects and inconveniences of these types, there are certainly some that are sufficiently
serious, namely, the X-rays appear not only where they are wanted, but in every direction. This fact has been proved by its malign consequences on the health and life of radiologists.

Progress in technique has however succeeded in creating a type of self-protecting X-ray tube of a simple and strong form, which sends the rays forward in a single direction. The axis of the cylinder, and in this way assures, among other technical advantages, the radical protection of the operator.

The first fundamental principle concerns the tube, which should never function unless enclosed in a protective apparatus which is impermeable to the rays: that is why, whether for radioscopy, orthoscopy or trocoscopy, the tube must be contained in a box with walls covered with anti-X-ray conducting material, the opacity of which to the rays is equal to 2 mm. of lead, or 3 mm. of glass. The lead lining of the walls of the radiographic cabinet where the switches and manipulating handles are, and where the operator is absolutely obliged to put the tube in action, must be at least 2 mm. of lead, and should be provided with protected handles; even the manipulation of the diaphragm and of the movable box should be made by means of handles similarly covered with lead.

Further, the radiologist should never proceed to make a radiological examination without being provided with anti-X-ray conducting gloves, closing hermetically, and sufficiently long to cover a good part of the forearm. The gloves should be constructed of anti-X-ray conducting material, even on the palmar aspect, although flexibility will be diminished thereby. The hands should always be protected, especially on the dorsal aspect, by a protecting layer, the opacity of which should not be less than the equivalent of \( \frac{1}{2} \) mm. of lead. The use of aprons and goggles of anti-X-ray material should be the rule, and similarly for a long observation, use of movable opaque screens either at the side or below can create even greater protection by limiting the field of observation in a frame impenetrable to X-rays.

Though so many precautions may seem to be excessive, they are not really so for protection against such an insidious and inexorable enemy. On the other hand, all this protective apparatus can be so ingeniously arrayed as not to incommode in the slightest the practical work of examination. The radioscopic examination, however, should be as rapid as a careful observation will allow. When it is necessary not to carry the patient, for example, to examine the abdomen, to displace certain organs, to test sensitivity to pain, the bare hand should never alone be used, but in order to avoid the superposition of another shadow, the hand is replaced by Holzknecht's "distriminator" which is only a kind of wooden spoon with a handle, the convex part of which, applied over the abdomen carefully, will take the place of manual palpation.

When the radiologist has to give demonstrations to other colleagues or students unfamiliar with radioscopic work, he should never carry out while the tube is working, but describe the object that he wishes to show first without the current and then illuminate the screen for a few moments and only resume the demonstration when the current has again been broken.

For the work in the darkroom which supports the tube must always be in the form of a cup or box of anti-X-ray material of an opacity corresponding to 2 mm. of lead. The radiographic couch should always be a little distance away from the protected cabinet where the switches and manipulating handles are, and where the operator is absolutely obliged to go to put the tube in action. This should be in such a position that the anti-cathode can be turned to the side away from that of the cabinet. The thickness of the lead lining the walls of the radiographic cabinet should not be less than 2 mm.

If the cabinets are constructed of material other than lead, their uniformity should be periodically controlled to avoid cracks or more transparent zones which in the long run might represent some risk. Such control, easily effected with the fluorescent screen while the tube is working, might very well be extended to the whole of the protective material.

The Röntgen ray room is the place where the need for protection is greatest, especially when it is a question of deep therapy with apparatus of high potential kept in action for several hours, and producing radiations of very great frequency, and consequently particularly penetrating.

In this case, the operator working the apparatus should be in a room dif-
ferent from that in which the patient is. Naturally reliance should not be put on the dividing wall, especially if it is a question of a slight partition wall. On the other hand, a wall of a certain thickness does represent a very good means of protection. The wall separating the manipulating cabinet from the treatment room should be covered with a layer of lead of at least 3 mm. thickness. The tube, further, should be in a protecting envelope, the opacity of which should be equal to 3 mm. of lead.

According to Pfahler, complete protection against the rays is never entirely obtained; more and more elaborate protection is necessary for specialists using radium or X-rays of high voltage. A film carried in the pocket for two weeks will give a good indication whether or not there has been excessive exposure to the rays. If the film is clouded protection is insufficient.

If the hours of exposure to the rays are lessened, and ventilation and rest increased, the symptoms which have been described may be attenuated, and future troubles avoided.

In 1923, a substance made of rubber, industrial to X-rays, was placed on the market, the process of manufacture being kept secret. This substance resists a difference of potential of 2,500 volts and a thickness of 3 mm. is equivalent to 1 mm. of lead; with 5.3 mm. it equals 1.7 mm. lead.

A study of the strength of the rays emitted by the Coolidge tube across the different methods of protection thought out for eliminating any harmful effects, has led to the conclusion that the rays pass through all the defences (metal casing, leaden cabinet, brick wall treated with barytes, brick walls lined with sheet lead, etc.) but in each very infinitesimal quantity that, under ordinary conditions where the operator and persons living on the other side of the wall may be, no damage to the skin or viscera is likely to be feared.

All these precautions naturally should be taken in factories required for making Röntgen ray tubes while the vacuum is being created, so that the workman employed on the pumps is kept away from the tube in action in the furnace by the wall of this and by anti-X-ray conducting glass of an opacity equal to 3 mm. of lead. A thickness of 4 mm. at least should separate the tube from the workman when testing apparatus for generating current of high tension, especially in the case of transformers for deep therapy, where the test has to be carried on for several hours at a tension of about 200,000 volts.

But, as has already been said, it is not only the X-rays which threaten the radiologists in the line of their work; it is also the gases given off into the surrounding air when currents of high potential are produced or directed and where the Röntgen tubes are excited.

How should protection against the injurious gases be secured?

In the first place, precautions should be taken to reduce their production to a minimum, and secondly to eliminate them as rapidly as possible. Apparatus without commutators and revolving switches always produce much less injurious gas than those the action of which is bound up with the continual jumping of the spark between the revolving mill and the sectors.

This is why in apparatus for diagnostic purposes as well as of apparatus for deep therapy, mechanical commutators are eliminated as much as possible and replaced by thermo-ionic valves, as, for example, the excellent apparatus with condensers.

In any case it is advisable that the apparatus generating the current of high tension should be enclosed in a special place from which only lines at high tension can come along channels which isolate them. It is important that in the room for treatment the line should be as short as possible and enclosed in an aluminium or brass tube of sufficient size and having the ends terminating in bulbs so as to avoid escapes as much as possible. In the same way, the spinterometer, when it is not working, should be kept as far as possible from the sparking point; it should be in the form of a sphere rather than pointed.

All these precautions, even when adopted will not entirely prevent the production of toxic gases. It is, therefore, useful to have large rooms, well ventilated and provided with fans which constantly renew the air. As it is a question of heavy gases, suction should be applied low down. In winter heating by stoves rather than by radiators should be practised because the former method allows of renewal of the vitiated air.

The precautions which all members of the staff should take to avoid electrical discharges, or, at any rate, to minimise the consequences dangerous, are as follows:

To have flooring that is a bad conductor: waxed wood, linoleum, cork, rubber. Floors of earthenware tiles or concrete are dangerous, especially when they are wet.
The line of high tension current should be at a height of 3 metres from the ground at least; suspended wires should be avoided. The aerial network should be firmly fixed, tested from time to time, and fixed in such a way that if the wires break they will automatically be drawn up towards the ceiling.

All the metal parts of the generator at high tension-stands, tube holders, orthoscope, and trocoscope ought to be electrically earthed (preferably by connecting up with piping for drinking water).

The installation of the current at low tension should be furnished with fusible valves and apparatus of high tension with automatic safety circuit breakers ready to act in the unfortunate event of a short circuit, as, for example, by a high tension wire earthing itself through the human body.

The operator manipulating high tension wires when naturally no current is passing through them ought in any case only to touch one at a time; he ought never to have the two poles in his two hands at the same time. If, unfortunately the circuit is closed and a high tension current is passing along the wire, the danger to the operator is much less if he is only touching one simple wire than if the high tension circuit is formed across his body by contact with the two poles.

The personnel should be instructed as to the risks of electrocution and on the importance of practising artificial respiration for a long time; exclusion of persons suffering from skin diseases, or the sequelae of syphilitic infection, diabetes or disorders of endocrine origin, etc., should be enforced.

The Committee of Hygiene of the Netherlands has proposed (1926) draft regulations to protect technicians and others in the vicinity from the action of X-rays.

The project provides for State permits for the installation of X-ray laboratories, a diploma as a specialist, etc. The report analyses the different methods of proposed protection.

A series of resolutions of international importance was voted at the Congress of Radiologists of the Soviet Federation held in Moscow in 1924:

*The medical man in the cabinet for diagnosis by Röntgen rays should be protected, in addition to an apron, goggles and gloves, by a wall lined with lead plates of a thickness of 3 mm. In cabinets for treatment by X-rays employing apparatus up to 150 kilovolts, a cabinet for the protection of the personnel is indispensables. Apparatus of more than 150 kilovolts should be divided up into three portions — one for the generator, another for the patient and a third for the personnel. Radiologists should have a four-hour day and limit themselves to five days a week. The persons employed should have two months' holiday annually and should undergo periodic examination to determine their state of health."

**Legislation**

There are at present no legislative enactments as to measures of protection for radiologists against the dangerous consequences of the rays. But professional societies in the different countries have taken up the question of obtaining insurance against damage caused by X-rays. Notification of cancerous dermatitis and other lesions of the skin from X-rays is obligatory in the Netherlands and in Poland and compensation is granted in Austria, Belgium, Czechoslovakia, Finland, France, Germany, Great Britain, Mexico, New York State, Sweden and the U.S.S.R.

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**Prof. F. Perussia**

(Milan.)
The raw materials used in the manufacture of rope are ordinary hemp, Manila hemp, Indian hemp, phormium, jute, coconut fibre, esparto grass, etc. For certain special work, rope made from straw is used. (For metal rope see article "Metallization").

The raw material for rope-making arrives at the factory in bales which, on opening and shaking, emit quantities of dust. Ropemaking may be said to be at the present time a mechanical industry, hand work being very rare. It suffices to mention that hand work comprises the spinning of the rope yarn and the "laying" of the rope or twisting of several strands of the rope yarn.

The work executed in mechanical ropemaking is very similar to that involved in the manufacture of hemp (see that article). After shaking, the bales are run through softening machines, in which they are moistened with an emulsion of oil and water preparatory to carding. This operation, which consists in pulling the flax through steel needles fixed on a board, raises much dust, though the fibres are oiled. The hemp which has been mechanically combed is spun on a frame provided with a funnel-shaped condenser to regulate the thickness of the strand fed to the fly spindle, which effects the twisting.

Cables are made by means of "laying" machines, which warp and twist the threads to form strands. Other machines twist several strands together to form the cable, while certain types of machines form the cables directly.

Fine string is almost always made by machine. The string passes through a bath of dressing or dye and is then wound into balls by machinery.

Old ropes, tarring or otherwise, are used for making oakum.

**Sources of Risk**

The dangers arise especially from dust, oils, tar and substances used in dressing and dying string. The risk of fire should also be mentioned.

Israelsohn, who made a calculation of the amount of dust present in a string factory at Orel (1927), found from 0.109 grm. per cubic metre to 0.453, according to the machines operat-
matter used are not infrequent, and tetanus has on occasions been caused by organisms present in the dust.

HYGIENE

Primitive methods of handwork in this industry are now for the most part replaced by the use of machinery, but dust production is in nowise diminished unless effective local exhaust is provided over the machines. Good ventilation is also essential and workers in this occupation should be chosen with a view to the elimination of those predisposed to tuberculosis, those with nasal obstruction, flatfoot and varicose veins.

For other data relative to hygiene and legislation, see the articles corresponding to the different vegetable fibres.

BIBLIOGRAPHY


Rubber or India-rubber Industry

French: Industrie du caoutchouc. — German: Gummi- or Kautschuk-Industrie. — Italian: Industria della gomma elastica or Industria della gomma. — Spanish: Caucho or Goma elastica.

CHEMICAL PROPERTIES

In 1736 Ch. de la Condamine sent from Quito to the Academy of Sciences at Paris some rolls of a liquid resinous mass known under the name of "caoutchouc".

Rubber is a natural product obtained by the coagulation of "latex" or "latex-milk" of certain species of trees very numerous in tropical latitudes, of which the principal are the Heveas (especially H. Brasiliensis Mill., Arg., of the family of Euphorbiaceae), the Castilloas, the genus Landophila and the majority of the laticiferous plants of the Asclepiadaceae.

The latex extracted from the rubber trees by means of tapping has the appearance of a white viscid liquid in which the rubber is in suspension in the state of fine globules. It varies in quantity from 10 to 40 per cent. (Heveas). Separation from the serum is effected in various ways, either by spontaneous coagulation, or by boiling, or dry by smoking or by skimming or more rapidly by the addition of certain chemical agents (principally acetic acid), or lastly by modern mechanical processes (although not widely in vogue) of filtration, centrifugalisation, crushing the ligneous parts, etc.

Rubber freshly cut is colourless, without smell, elastic, extensible, a bad conductor of heat and electricity, and has specific weight of 0.910-0.942. At 3-4° C. it becomes rigid (it freezes); heat swells and softens it, but its elasticity is only momentarily lost. It unites with itself completely; dissolves in hydriodic acid, carbon bisulphide, petrol benzine, and naphtha (which can absorb as much as 30 per cent. of their weight in rubber).

Rubber is now regarded as a hydrocarbon of the aromatic series belonging to the family of terpenes represented by the general formula C_{n}H_{2n}. Only slightly affected by dilute acids and alkalis, this non-saturated hydrocarbon can, under certain conditions, fix certain elements with strong affinities (chlorine, bromine, iodine, oxygen, sulphur). The combination with sulphur is the most interesting, because it is the starting point for its industrial use. (See below, Vulcanisation.)

Among the resinous gums used in this industry, either alone or combined with rubber, to the view of the similar uses to which they are put, gutta-percha and Balata may be mentioned. The former is contained in the latex of certain plants of the family of Sapotaceae (coming from Malacca, Sumatra, Borneo, etc.), while Balata is a latex of the Minusops Balata Gaert, and of the M. Globosa Gaert. of the family of Sapotaceae (from Guiana, Venezuela, Brazil, and the Antilles). Industrially, however, other substitutes are used (rubber waste which requires pulverisation and grinding after washing), recovery rubber (see below, Rubber recovery), and artificial rubber which is far removed from the real article. Artificial rubber is only a chemical combination of vegetable and mineral oils (linseed, colza, rape seed, Black Sea rape, cotton seed, etc.), with more or less sulphur added. Sometimes mineral oils are added to vegetable oils. Thus rubber is obtained by synthesis, starting from isoprene and especially isoprene (C_{5}H_{8}) and methylisoprene (C_{6}H_{10}) converted into synthetic rubber by polymerisation (by means of heat under pressure or of catalysts, or of metallic sodium and heat). (See also article "Naphthaline").

Although processes in the rubber industry may vary slightly in different countries, it is nevertheless possible to give a general description of these, because the differences are not so great as might be imagined. Like all other chemical industries, however, the rubber industry is constantly experimenting with new substances, the use of which is at one time adopted and at another abandoned.

In addition to the gum resins of the rubber substitutes, the industry uses quite a number of substances of which the most important will now be mentioned. These are mixed with the pure rubber in order to conform to special properties (increase in the density of the mixture, acceleration of the vulcanising process). Certain compounds are used to colour the mixture (plumbate of lead, or graphite, or humin, or zine sulphide, cinnabar, zin' white, white lead and other lead compounds —
especially in the manufacture of rubber shoes — and even arsenical colours); other agents used to dissolve the sulphur chloride, or the rubber are petrol, benzene, carbon bisulphide, acetone, dichloromethane, carbon, tetrachloride, etc.; others used in the charges, or batches, are sulphates (plaster, barites), carbonates (of lime and lead). Use is made, too, of silicates (talc, asbestos, kaolin, etc.), and of various mineral compounds such as chrome yellows and greens, etc.; these will be mentioned when describing the different processes.

**TECHNOLOGY**

Raw rubber usually contains impurities (water, resin, wooden debris, leaves, sand, earth, etc., with which the juice has been contaminated at the time of collection). These are got rid of by a preliminary treatment steeping in water at 40-50° C., sometimes alkali, or acidulated. The rubber is then broken up, being subjected to washing in cold water; then grinding takes place in such a manner that the pieces squeezed between the rollers are freed from the foreign bodies contained in the interior of their mass. The sheets of rubber after grinding are next dried and pass to steam-heated calender rolls; the rubber gets warm, softens, becomes plastic and takes on a compact consistency and homogeneous texture that had been lost during grinding. If the rubber is to serve for the manufacture of “fine sheet”, it is treated in a disintegrator or “devil” — a cylindrical apparatus in the interior of which revolves an iron drum with its surface studded (as is also the interior wall of the cylinder) with spikes.

The rubber obtained is subjected to stronger pressure in order to cool it and is then in the form of a compact parallelopiped (block) or cyllindroid, and is transferred thence to a cellar and kept at a low temperature for some time (freezing). At the proper time the block is sawn into “fine sheet” and the product, absolutely pure, is ready to be worked and undergo vulcanisation by heat or cold (see later).

Purified and prepared as described, the rubber can also be mixed with the vulcanising agent, the substitutes, the adjuvants, the batches and the necessary colours. This latter operation is done in different ways, either in the making up or the vulcanisation, according to the nature of the ultimate product required.

**Mixing.** — The masticated rubber (rarely frozen) is immediately subjected, together with the other substances, to compounding; measuring and weighing the different compounds can only be regarded as dangerous when it is a question of toxic compounds handled in absence of the necessary precautions. If the grinding, crushing or sieving of the required compounds (of lead, antimony, aluminium, iron, calcium, tin, and zinc) are done, all contamination of the atmosphere by dust must be prevented by the use of closed apparatus or locally applied exhaust ventilation.

In the case of volatile products, e.g. aniline, closed receptacles should be used. In an American enquiry (Ohio) in 1914, two cases of aniline poisoning were reported at this stage of the manufacture.

Among the chemical substances used to accelerate vulcanisation (litharge and less frequently basic sulphate of lead or white lead) are aniline, toluidine, piperidine, certain aldehydes such as aniline-formaldehyde, ammonialdehyde, certain aliphatic amines such as hexamethylenetetramine (ethyl diphenylguanidine, thiocarbanilide paraphenylenediamine (no longer used), diphenylguanidine and other substances more or less toxic (see the corresponding articles).

Generally speaking, the inclination in the trade is to suppress the use of the more toxic accelerators as, for example, paraphenylenediamine, thiocarbanilide, and even aniline.

**Compounding.** — This is done by kneading by means of smooth steam-heated rolls, which yield a very homogeneous mass ready for further treatment. For certain purposes, however, the rubber mass is softened by rolling out and calendering, in order to obtain very regular thin sheets. As the mixture is carried round the rolls, much of the dry powder falls off and is caught in a tray underneath the rollers, and the mixer has to sweep it into a pile, scoop it up with a shovel, and throw it back on the revolving machine. He cuts off the rubber sheet as it emerges from between the two cylinders and throws it back on the mixing mill until the powder is thoroughly incorporated with the rubber.

The dangers present are especially those arising from dust and fumes (principally aniline, as the other accelerators only give rise to minimum traces of vapour; the American enquiry already referred to found at this stage nines of lead, antimony, and aniline). Among 252 workers, 22 definite and 4 suspected cases of
lead-poisoning, and 3 of aniline-poisoning were reported. The danger was held to be serious in 13 out of 21 factories owing to failure of satisfactory removal of dust, and fumes, ignorance on the part of the workers, and insufficient welfare arrangements.

Good general ventilation and locally applied exhausts for certain of the mills (where toxic products are used) should be provided, although hoods in connection with the mills have been stated to render the work difficult.

Making up. — Rubber articles are made either supple or hardened in shapes determined by various processes which are included under one or other of the following operations: cutting out of a mould, pressing into cylindrical form, moulding. Flat pieces (washers, shoes, erasing rubber, etc.) are made by cutting the sheets as they come from the calander, or by assembling them on a mandrel at the time of vulcanisation. The parts to be joined up are also sometimes united by means of rubber solutions (see below, Rubber solvents) or by vulcanisation by heat.

Extruding serves to make hollow or flat articles by means of an Archimedean screw, an apparatus in the form of a horizontal cylinder in the interior of which a shaft provided with a helicoidal paddle causes the paste to move forward by forcing it against the front end and ejects it through a die plate fixed at that spot. The extruded material is then set in a mould. The parts to be vulcanised are inserted in the mould, and the mould is closed and heated by steam, or plate presses or moulds with heated walls. The apparatus takes the form and size suitable to the articles to be vulcanised.

For vulcanisation in dry air, there are presses with several plates, annular moulds with spaces communicating with one another; vulcanising pans for tubing, several dozens of yards in length, moulds like shells for pneumatic tyres, and even an autoclave press for rapid vulcanisation of tyre casings for motor cars. Vulcanisation for soles and corsets is done in a heated chamber (rubber shoes). Vulcanisation by diffusion does not require the mixing of the ingredients with rubber before sloping (cold cure). As soon as the object is ready, it is dipped in a vulcanising bath, which can be hot (melted sulphur at about 130° C.) or cold (solution of sulphur chloride in a solvent, such as benzene, carbon tetrachloride, carbon bisulphide, etc.). Combination between the sulphur and the rubber is effected on the surface, and the liquid passes to the interior by capillary attraction. The articles, freed from the layer of sulphur adhering to their surface, are then passed into a stove.

Shaped articles are also vulcanised by exposing them to the vapour of sulphur chloride.

The cold cure process, it should be noted, is now very little used, its utilisation being only in the proportion of 1 to 100 as compared with vulcanisation by heat.

The process of heat vulcanisation does not present very great dangers, particularly when in a well-managed factory. It is heavy, unpleasant work, if the articles are not conveyed mechanically and unless measures are taken for limiting the escape of steam and for keeping the temperature of the workroom low. It should be recalled that the decomposition of sulphur chloride by water gives off sulphur dioxide, yellow sulphide or antimony gives off hydrogen sulphide gas. Apart from the unpleasantness resulting therefrom, mention should be made of the dust (talc, etc.) and...
especially of the vapour of solvents used in the cold cure process (carbon bisulphide, benzene, petrol, carbon tetrachloride, etc.).

If the work of vulcanisation is done on any scale in small workshops (repair work or dry-cleaning) dangers may be sufficiently pronounced on account of bad general ventilation and especially from the use of the solvents without the necessary precautions. The surface to be repaired after preliminary rubbing and cleansing with a rubber solvent which on evaporating becomes viscous, is next coated with a liquid known under the name of “vulcanising acid”, which gives rise to the physicochemical changes necessary to enable the rubber to adhere perfectly under the application of strong pressure. The acid in question is only a mixture of benzene, carbon bisulphide and mono-chloride of sulphur (the last in the proportion of 2 : 1,000), sometimes only of benzene and petrol.

Stringent regulations have been passed for cold vulcanisation: dipping to be done in a closed apparatus (with downward exhaust ventilation of the fumes); a travelling belt to carry automatically under cover the objects dipped into a well-ventilated drying chamber. Carbon bisulphide should be replaced by benzene, and, better still, by carbon tetrachloride, dichloroethylene (see these articles), etc. The cold cure should always be done in a well-ventilated room with arrangements for the diminution, as far as possible, of the unpleasantness due to heat and humidity.

Rubber Solutions

Large quantities of rubber solution are used for making articles by the dipping process, coating and cementing. Coating solutions more or less thick are prepared by the use of rubber, either pure or mixed, and dissolved in petrol or benzene. For joining special articles rubber is mechanically prepared by balata or mixed with gutta-percha. Sometimes the solution is prepared by hand in open vessels; but in all well-managed factories it is mechanically prepared in a receptacle provided with localised exhaust ventilation. The solution is handed out to the workpeople in cans provided with a cover and aperture in the form of a valve to prevent evaporation. If the solution is to be sent out in tubes the filling is done mechanically. This operation requires a large number of workers who are all exposed to a degree of danger varying naturally with the precautions offered by the technical organisation.

The solution is used to fix or cement objects (shoes, pouches, sanitary goods, rubber clothing, bandages, toys, etc.); it is also largely used for making, by dipping, articles previously made with “fine sheet”; or it is sold as solution in tubes.

Danger. — Vitiation of the air by solution fumes, fire, and explosion.

Hygiene. — In making solutions only hermetically-closed apparatus should be used, provided with efficient exhaust ventilation; cans should have covers; ample cubic space per person with mechanical ventilation is essential. Hand labour should be replaced by machinery, although practically this offers certain difficulties.

Work with “Fine Sheet”

As has been said above, this serves for making a number of small, fine but flexible and elastic articles (baby feeding bottles, teats, nipples, finger-stalls, gloves, balloons, etc.). The articles are made by moulding or cutting and welding. Their vulcanisation takes place by dipping into a molten bath of sulphur or by the cold cure. These articles are prepared by a still simpler process (dipping) which consists in dipping celluloid or wooden shapes in a rubber solution, setting them to dry, then dipping again and again until the layer of rubber is thick enough. The operation is done in an apparatus completely closed and provided with exhaust ventilation. The dipping of the shapes is also mechanical as indeed are all subsequent operations.

Dangers. — Toxic vapour of the solvents (benzene, carbon bisulphide, etc.), unless exhaust ventilation is well adapted, or in absence of the necessary precautions.

Hygiene. — Downward exhaust ventilation should be installed and if the operation is not done mechanically the dipping troughs must be protected by a method analogous to that described later for spreading.

Manufacture of Spread Goods

Fabrics can be coated with rubber solution or woven with threads previously encased with rubber, or by the application of a thin layer of rubber. By the last-named method the cloth and then rubber sheeting is passed between the heated rollers of a calender which press the rubber into the fabric. The spreading of the
solution on the cloth is effected by a "spreader".

In principle, the spreading machines carry a drum on which the pieces to be impregnated are rolled. The cloth is drawn over the chests by a driven cylinder and receives, as it passes, the solution in a more or less fluid condition. This covers the cloth with a layer of uniform thickness by means of a spreading knife or "doctor" suspended so that it almost touches the outermost roll. The cloth is then drawn on to heated tables (100-120° C.) where the solution, penetrating into and attaching itself to the fibres of the cloth, solidifies on the evaporation of the solvent. During this passage evaporation is particularly active over the central tables of the machine and the quantity of vapour from the solvent depends naturally on the composition of the solutions used. In fact though the solution may contain 1 kg. of matter in 2 kg. of solvent, the pure solution is made on the contrary in 20-40 kg. of essence. The application of the solution on the cylinders may be done by hand by the worker who spreads it by means of a small wooden scraper, but the operation is generally effected mechanically (by dipping in a solution bath after which the cloth passes between spreading knives).

Danger. — Fumes of the solvent (especially benzene). Danger of fire and explosion.

Hygiene. — Locally applied exhaust ventilation to remove the toxic vapours facilitated by use of spreading machines provided with apparatus for recovery of the solvent. To effect the latter the cloth, after having passed the spreading knife, is carried into a passage way formed of two plates, the interior of which is heated by steam. This passage can be widened at will so as to assure more or less volatilisation as desired. The vapour is aspirated by a fan and passed into a refrigerator where it is condensed. Mechanical ventilation also can be applied along the sides or above the spreading table. In this case the hood with vertical duct to be effective should be prolonged along the sides by means of movable plates reaching as far as the level of the table.

While the removal of the vapours should be downwards across the floor, fresh air should be introduced from above and directed downwards by a plenum system.

Precautions must be taken against fire and explosion. Spreading machines should be earthed to remove from the cloth the static electricity with which it becomes charged during its passage through the cylinders.

In certain circumstances the belting, the pieces of cloth, the jets of liquid and even the workers themselves become charged with static electricity. A discharge may then take place between two bodies with a perceptible difference of potential, and such a discharge is likely to cause combustion, if it takes place in a mixture of air and combustible fumes.

According to Milne (1923) the problem consists in maintaining all bodies in the danger zone at the same temperature. The contents of the spreader, of the piping and the framework of the machine should be effectively earthed. A general system of damping the atmosphere up to about 40-45 per cent. should be instituted in order to deflect the charges of static electricity present prior to the passage of the product through the machine.

Each recipient and each jet or current of water or of vapour should be earthed at its source; the workers should wear shoes with metallic soles or nailed soles, etc. Precautions should be taken in regard to the transport and storage of the solutions in the spreading room.

The covering of the thread for weaving should be done in a separate room capable of being closed and organised in such a way that the process does not demand the continual presence of the workman.

Pneumatic Tyres

This branch comprises a whole series of operations which vary according as to whether it is an outer cover or an inner tube which is being manufactured. The latter is but an India-rubber tube fashioned by means of a mandril specially adapted for the purpose. The tube from the mandril is vulcanised in the curing pan and converted into a complete ring by turning up the ends on a special form and cementing the lips together with solution.

For the outer cover four or five strips of impregnated cloth covered

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1 It is very important to know at any moment the concentration of benzene in the air of the spreading room. During the enquiry of Bridge and Price (1917), analysis showed that when seven spreading machines were at work there were 211 parts of benzene per 10,000 of air; behind eight spreading machines near the fan 163.5 per 10,000; between six spreading machines at a height of 30 cm. from the ground 3.7 per 10,000; at the same place 30 cm. from the ceiling 4.6 per 10,000. An increase in the renewal of the air of the room (from 25 to 67 per hour), replacing of benzene by xylol, and medical supervision rapidly improved the health of the workmen.
with solution are super-imposed one on the other to constitute the casing which is then completed by placing upon it the tread, which may be smooth or indented.

The casing of the outer cover, made as described, is taken from the metal core which has served for its manufacture and, in its place, an air chamber is introduced. The whole is placed in a mould consisting of two metal shells, the air chamber is blown up until it assumes the shape exactly, and vulcanisation takes place in the autoclave. Transport of moulds to different sections of the factory is done by means of an overhead railway with carriages carrying chains to which the moulds are hooked.

The work of polishing and buffing in the manufacture of pneumatic tyres to-day is very rare. Danger from dust raised in this operation only concerns, therefore, the few factories which still continue to do it. Similarly, lead salts are almost entirely dispensed with now in the making of pneumatic tyres.

Varnishing

The making of waterproof shoes deserves a special note. Once finished the shoes undergo drying followed by a coat of varnish made up of artificial black dissolved in petrol and turpentine which is applied on the golosh and even on the external sole. Vulcanisation takes place in a stove, heated by steam, the air of which is renewed at the end of each operation while fresh air is brought in by pipes passing through the lateral walls. Ventilating openings installed in the upper part allow the steam and toxic gases to escape.

Danger. — Vapour from solvents, fire, and explosion.

Hygiene. — As already described above.

Rubber Recovery

Extraction of the old rubber from the manufactured goods no longer in use is not an easy matter in view of the great diversity of composition of the manufactured rubber. There may be an excess of free sulphur, of mineral matter, or charges of metallic substances, etc., of which the rubber has to be freed by different methods, all, however, having a certain resemblance. The foreign matters are attacked by acids, alkalis, or neutral salt solutions. The recovery involves a long series of different operations according to the product handled. The processes followed may be mechanical (washing, grinding, sifting, etc.), or physical (heat, superheated steam solvents), or chemical (acids, sulphites, sulphides, etc.), upon all of which it would not be worth while to dilate as each factory applies methods of its own.

Danger. — Dust, fumes of the solvents, sulphur, hydrogen gas, etc. Reference is made in the literature of the subject to cases of anilism (Ramhosek, 1913), to lead poisoning, and to ill-effects from the "smother" and from heat.

Hygiene. — Prevention of dust, gases and irritating or toxic fumes by the use of closed apparatus and exhaust ventilation.

Dyeing

Rubber can be varnished with colours with or without a previous coating of size. The dye is also made to act on the mass by means of a bath of copper sulphide and ammonia or chloride of ammonium for black, sulphide of copper and ammonium chloride and chalk for green, etc. The mass can be mixed with colours such as cinnabar, white lead, yellow sulphide of antimony, etc.

Dangers and hygiene. — The dangers are those common to the varnish and lacquer industry. Decomposition of the yellow sulphide of antimony by acids gives off hydrogen sulphide.

Statistics

Austria. — In 1911 two fatal cases of benzene poisoning were reported and between 1914 and 1918, six cases of carbon bisulphide poisoning with mental symptoms were treated in the clinic for psychiatry in Vienna. The Factory Department drew attention to the risk of contamination from blowing sanitary articles with the mouth and urged replacement of this method by a pump.

Belgium. — In 1895 an enquiry by Gilbert brought to light 16 cases of illness from carbon bisulphide in the rubber industry, the symptoms being inco-ordination, delirium, psychical disturbance, paresis, etc. Application of preventive measures resulted in 1904 in very considerable improvement in the health of the workers. During the war, work ceased, but on its resumption, at the end of the war, cases again came to light. Enquiry by Vandenpladen (1920-1921) in a factory for toy balloons, etc., vulcanised by dipping in a solution of 1-2 per cent. sulphur chloride in carbon bisulphide, revealed the fact that 8 out of 6 examined had moderately severe symptoms of carbon bisulphide poisoning, while 11 mounters (fairly old workers)
were less affected (2 with some paresis, 6 with headache and digestive trouble); 16 out of 20 blowers (using compressed air) had previously been affected by carbon bisulphide and the majority of them at the time of the examination suffered from headache and vertigo; 6 had some degree of paresis.

Germany. — According to Laudenheimer, in the factories of Leipzig, employing about 728 workers, of whom 219 were employed in vulcanising, 31 cases of moderate poisoning and 19 cases of nervous diseases were treated by private medical men or in hospital between 1874 and 1908 — all attributable to carbon bisulphide. According to the same writer every workman who is exposed to the action of this substance inevitably runs a risk of more or less severe poisoning. In 1905 von Harmsen gave the result of an examination of 220 vulcanisers in 7 factories at Cologne, made in 1901. 112 of the workmen, i.e. 46.3 per cent., were ill, 18.6 with gastro-intestinal affections, 11.3 with pharyngeal catarrh, 6.5 with anaemia, and 0.9 with nervous affections. The data from the local sickness insurance society of Leipzig (1910) gave a very high morbidity rate to this category of workman. Thus, among 2,228 men there were 1,041 cases of sickness yearly with 20 deaths. The inspectors of factories have reported several especially among those employed in the spreading department. The Inspectorate consequently issued by the Secretary of State immediately issued instructions for ventilation and distributed leaflets and warning notices for the benefit of the workers and "petrol" was substituted for "benzene".

Italy. — An enquiry by Cicala (1921) covering the small repairing shops in Rome enabled him to say that a third of the workers employed (20) showed signs of benzene poisoning. Fatal and serious cases were reported in Milan among persons employed in waterproofing cloth (see article "Benzene").

Netherlands. — A fatal case of benzene poisoning was reported in 1916 in a spreading department. The Inspectorate immediately issued instructions for ventilation and distributed leaflets and warning notices for the benefit of the workers and "petrol" was substituted for "benzene".

United States. — A detailed health enquiry by Hayhurst in 1914, in Ohio, in factories employing 11,427 workers, of whom 1,942 were women, covered the conditions in all of the several processes. Effects from benzene were frequent; less than 1 per cent. were in contact with carbon bisulphide. The enquiry revealed 99 cases of poisoning of moderate severity from carbon tetrachloride. Cases of lead poisoning were also discovered in certain factories. The first of such cases reported in Great Britain. Between 1910 and 1921, 74 cases of lead poisoning were reported in the mixing process.

Pathology

Besides the local action of certain substances used in the rubber industry (carbon bisulphide, sulphide of antimony, accelerators, etc.), the general effects of the industry on the human organism should not be lost sight of, such as the condition of the atmosphere in regard to dust content, humidity and warmth, the human factor in relation to fatigue — from posture, speed of the machines, the carrying of heavy loads, etc. — and again in relation to poisonous materials (aniline, carbon, bisulphide, benzene, petrol, lead compounds, etc.).

While the various articles already deal separately with these different substances, certain details may be here noted. Thus, hexamethylenetetramine sets up an eruption resembling
measles with formation of pustules which have been attributed to its decomposition into formaldehyde and formic acid. Benzene is said also to set up a characteristic dermatitis occupying the interdigital spaces and accompanied by redness, itching, swelling and vesicles, while the rest of the hand remains intact. A more or less severe eczema has been attributed to the handling of certain substances which, during mixing, set up conjunctivitis. Poisoning by sulphur chloride is rare (see above, Vulcanisation). During the preparation of rubber substitutes from oil and sulphur, large quantities of hydrogen sulphide are given off which require careful removal. Lesions, set up by cinnabar, known under the name "rubber sickness" have been described as occurring among persons employed in making artificial teeth from gutta-percha. The German dentist Lazarus has described 20 cases of dental caries among his own staff, complicated at times by necrosis of the lower jaw, the cause of which was, however, not recognised. Wide use of talc can also cause respiratory affections (see article "Talc"). Gilbert, lastly, has described cases of deafness and diminution of the acuity of hearing among the workers exposed to very loud noise from the machines.

HYGIENE

In the rubber industry, and especially in the departments using solvents and solutions containing volatile compounds, stringent regulations for unhealthy and dangerous trades should be applied. Factories should not be in populous centres unless measures are taken to suppress the unpleasant smells. The buildings should be constructed of incombustible materials; and every precaution against fire and explosion must be taken (see articles "Benzene", "Petrol", and "Carbon Bisulphide"), and also against unnecessary noise; use of fuel giving rise to much smoke should also be limited. The floors should be impermeable and wood on walls and elsewhere should be cemented or plastered; fireplaces, hearths, lights, etc., should be disposed in such a manner as to prevent fire, and no one should be allowed to enter with naked lights; burning of debris, etc., should be prohibited; necessary precaution must be taken in drying; sand should be available for the workers to extinguish a fire on its first appearance. Special precautions are necessary in the storage of inflammable materials in the workrooms (only sufficient for the day's requirements to be kept in closed receptacles, etc.), and for the removal of waste; all escape of steam and excessive heat should be controlled as far as possible in order to maintain as reasonable a temperature and humidity rate as possible. Cubic space should be ample for each person (at least 30 cubic metres per person — the German Factory Act allows 20) with constant renewal of the air.

Processes giving off toxic vapours should be effected as far as possible in closed apparatus or at least in apparatus completely covered and kept under a negative pressure. A recovery installation for the spreading machine, besides lessening the temperature of the atmosphere, is pointed out by inspectors of factories to present considerable economic advantage from recovery of the toxic products by condensation. The workers should be protected against the risk of poisoning by the toxic products employed, especially for mixing. All noxious gases should be condensed and certain substances should be replaced by others less toxic (carbon bisulphide by petrol, carbon, aniline, etc., by other accelerators).

A mixture of 80 parts of lead compounded with 20 parts of pure rubber is now in use. This mixture is homogeneous, is sold in sheet form, and is ready for direct incorporation with the other ingredients on the rolls and offers the hygienic advantage of causing no toxic dust (Klein).

Workers should be warned of the dangers of the work. The residuary waters should be deodorised by chloride of lime, or some equally efficacious substance. Effluents which are not in a condition to be run directly into the sewer should be collected in tanks before their evacuation and should be passed through a metal grid to hold back particles in suspension. The usual precautions prescribed for persons employed in unhealthy industries should be observed. Bottle of soda in solution has been recommended for application to the uncovered parts of the body in the case of hexamethylenetetramine rash.

LEGISLATION

The Regulations issued in Germany (Order of 1 March 1900), in Prussia (20 February 1910), in France (20 January 1909, Ministerial Circular), in Great Britain (Special Rules of 1897; Regulations No. 721, 1922; and No. 329, 1922) relate only...
to processes involving contact with carbon bisulphide.

The recent British legislation governs vulcanisation and treatment of rubber involving the use of toxic volatile solvents, and compounding processes in which lead or lead compounds are used. The decrease in the number of cases of poisoning in spite of the greatly increased use of these substances is due to the enforcement of ventilation rules whereby the toxic vapours are drawn off by fans, and lead dusts are removed in a somewhat similar manner.

In 1922 Regulations requiring periodic medical inspection and locally applied exhaust ventilation wherever dry compounds of lead were used led to the use of "plastic rubber", that is, the incorporation of dry lead compounds in mother batches of rubber to the extent of, perhaps, 90 per cent., so that portions of the mother batch could be used instead of the dry compounds themselves. Where this method has been adopted, there being no lead dust generated, the occupier is absolved from the necessity of providing not only exhaust ventilation but also medical examination.

Netherlands. — The regulations enforced in the Netherlands for workshops in which poisonous fumes and dusts are liberated also apply to workshops where carbon bisulphide is utilised.

Argentine women are excluded from the manufacture of waterproof materials and from workrooms where carbon bisulphide and benzene are given off (rubber factories and manufacture of rubber articles).

France. — Women are excluded from workrooms where rubber solutions are made or applied after solution in essential oils and carbon bisulphide.

Young persons under 16 are excluded from vulcanising processes (with carbon bisulphide) in France, Canada, Germany, Great Britain; under 16 years in Belgium, Canada (Quebec), Spain (boys); boys under 15 years are excluded in Italy from vulcanisation by carbon bisulphide and chloride of sulphur, preparation of rubber solutions and their application; female young persons under 21 are excluded in Italy and Spain. This exclusion applies also to the coating with rubber solutions of articles to be made waterproof.

The special legislation cited above includes mechanical suction or use of machines and closed apparatus for the operations giving off toxic vapours; efficient general ventilation; reduction of hours to 5 per day with a pause after every 2 or 2½ hours of work; posting up of the Regulations; general welfare provisions.

In Germany and Great Britain periodic medical examination of workers (monthly) exposed to bisulphide of carbon and dry lead compounds is enforced.

For notification and compensation, see the articles on various toxic substances.

BIBLIOGRAPHY


Dr. A. Hamilton
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Salicylic Acid


Salicylic acid — symbol C₇H₆(OH)₃CO OH — forms white odourless needles with a sweetish taste. It melts at 155° C., volatilises at 200° C., and is but slightly soluble in water.

It is got by the action of carbonic gas, at a pressure of 5 kg., on dry sodium phenolate.

In industry it is used chiefly for the preparation of nitric colouring agents. (For symptoms, see articles “Phenols” and “Aniline”.)

Women are excluded from the manufacture of salicylic acid in Argentina and France (when manufactured from phenol), and boys under sixteen and women under twenty-one in Spain.

### Scavengers, Road Makers and Road Menders


This article deals not only with workers employed in towns in collecting household refuse, and street cleansing, but also with those engaged in tarring roads, in laying and repairing drains, making and repairing country roads (road-men), preparing and laying metal for surfacing roads, and emptying sewers and removing all kinds of liquid sewage.

The composition of the sewage and of the refuse collected varies according to latitude, climate and season; but that of liquid sewage depends on the varying nature of the source of the water used, whether from houses, or, more usually, from workshops or factories.

### Street Sweepers

Street sweepers are an important group of town scavengers.

The collection of street refuse represents a hygienic problem of great importance, which, however, has been simplified during the last thirty years by the changed conditions of the present day, as regards the composition of the street refuse, owing to the reduction, and even the disappearance, in some localities, of animal traction, as well as by the changes that have taken place in the construction and upkeep of street surfaces. Indeed, the composition of street waste varies from a multiplicity of causes, among which may be mentioned the geological formation of the ground, the products of local trade, and progress in urban hygiene.

Where removal of refuse is effected by means of a spade, for lack of modern machinery, and where the streets are inadequately watered, those employed must obviously inhale a dust-laden atmosphere, more or less charged with germs, many of which adhere to the particles of dust. Street sweepers working in towns where there is a lot of traffic, especially in streets crowded with people and animals, are exposed, if the local habits of cleanliness, or the individual habits of the population, are not all that can be desired, to the danger of inhaling numerous germs, which are decidedly more plentiful in the vicinity of hospitals and of buildings where certain kinds of organic animal and vegetable substances are treated, such as slaughter-houses, tanneries and silk spinning mills.

Reference to pathogenic microbes immediately suggests tubercle bacilli; but, generally, the virulence of these is lessened by being dried, and also by the sterilising action of the oxygen of the atmosphere and of the solar rays.

As a proof of the danger from microbes in street dust, it is only necessary to refer to an English enquiry, according to which there were fewer
cases of illness among children coming from those neighbourhoods where attention was directed to the surface and cleanliness of the streets, all the other hygienic and social conditions, such as housing, food and clothing, being, of course, similar.

An enquiry conducted by Allevi in 1914 dealt with 217 street sweepers of Milan, among whom he found the following troubles: flat-foot occurred in 64 cases with an occupational origin, due to the method of carrying on the work, to the daily duration of work, and the number of years of working experience. The candidates suffering from flat-foot adopt a posture which Annandale calls “attitude of rest”; it enables the subject to carry an overload with the foot in a position which encourages the development of flat-foot; in this position the lower limbs are set square, so that the foot is rotated externally and pronated. Gastric and intestinal disorders occurred 43 times. Conjunctivitis due to cold and dust was present in 18 cases. Respiratory diseases claimed 15 cases, and rheumatism 13 cases. Pulmonary tuberculosis is not common, or at any rate does not exceed the average found in other occupations. Allevi explains this fact by the bactericidal action of sunlight, and by work in the open air. Out of 1,000 street sweepers who were members of the Mutual Assistance Society, the morbidity rate was 48.8 at ages 15-34; 65.77 at ages 35-54; and 124.70 at ages 55-74, and the mortality rate 0.63 at ages 15-34; 2.41 at ages 35-54; and 10.56 at ages 55-74. The cases of pulmonary tuberculosis were, for the three age-groups as stated above and per 1,000, 6.74, 10.21 and 9.99; the mortality 1.90, 3.32 and 3.92 respectively.

SEWER-MEN

It is becoming increasingly usual in large towns to construct special tunnels in which are placed water pipes, gas pipes, and electric mains. In other towns the sewers themselves constitute large tunnels, easy to inspect and readily cleansed which are also spacious enough not only to fulfil their original purpose, but also to have space for special conduits for water, drinking water, and telephone cables, e.g. Paris.

These tunnels are sometimes very deep, 20 or 30 metres or more, and may be connected — especially for residuary water — to factories, the waste from which, invariably or under special conditions, gives off injurious emanations. Lack of light, damp, cold, gases and fumes constitute a health risk for persons whose lot it is to work in these tunnels.

Sewer-men are in contact with liquid detritus, abounding in organic matter, which readily putrefies and gives off large volumes of gas; it is the cause of the condition known under the name of “mephitism”. This form of poisoning is connected with the presence of gases which are sometimes only unpleasant, e.g. ammoniacal fumes; but which sometimes are genuinely toxic, through the action of a mixture of gases varying in composition, according to circumstances, but generally consisting of ammonia, ammonium sulphide, carbon dioxide, hydrocarbon, chlorine and sulphuretted hydrogen. The nature of the toxic gases and their concentration explain cases of poisoning which are gradual and imperceptible in development, as well as cases of sudden onset, unexpected and serious, which sometimes advance swiftly to a fatal termination (“sewer-men’s stroke”).

The inhalation of putrid gases, even in small quantities, but recurring frequently or from time to time, causes disorders of nutrition; weakens the organism; brings about changes in the composition of the blood, resulting in anaemia; and paves the way for infectious diseases. A large number of clinical observations and experimental enquiries have led to the recognition of a connection between mephitism and actual disease, more particularly between sewer gases and intestinal diseases, e.g. typhoid and cholera. It should be recalled that Marchionni, before the discovery of the Eberth bacillus, had affirmed that sewer gases were the direct cause of typhoid fever. In Italy, Di Mattei and Sette; in France, Brouardel and Chantemesse; in Germany, Eichorst; and in Australia, Badham and Purdy have reported cases of typhoid epidemics among sewer-men or in houses near sewers which had been opened in consequence of repairs or similar operations.

Among sewer-men, cases of jaundice have also been observed, caused by spirochetosis. And fatal cases of pulmonary spirochetosis (Heim de Balsac, Agasse-Lafont and Fell).

Experiments have proved that the inhalation of these gases diminishes the resistance of the body to infections, particularly as regards the typhoid bacillus, and the bacillus coli, even when the experimental infections were effected with weakened germs, or in very small quantities (Di Mattei, Alessi, Puntoni, Ronzani). Apart from
this in the case of sewer-men, it is essential to recall the possible danger of in contact with the typhoid bacillus, by direct contact with the sewer liquid.

In the case of the men who work in tunnels at the construction and maintenance of different conduits, instances of poisoning have been reported by gases and fumes of the most varied origin, which may penetrate into or become liberated inside the tunnels, such as carbon dioxide, sulphured hydrogen, chlorine, carbon monoxide, acetylene, hydrogen and arsonured hydrogen, methane, hydro-carbon or nitrous fumes.

Among these workers cases of pharyngitis, bronchitis, broncho-pneumonia and rheumatism occur; there are also cases, some of which are fatal, of poisoning by inflammations from the soil, and from coal gas; other cases known consist of cerebral congestion with slight paralysis (Cimaduomo, 1929).

The dangers being similar to those incurred in coal mines, a proposal has been made that safety lamps shall be used in order to detect the presence of inflammable gases, especially methane. An enquiry was carried out in 1925 by Katz, Metter and Bloomfield for the United States Bureau of Mines, in three towns, with the object of studying the gases present in these tunnels. The gases found were classified in three groups: toxic gases, asphyxiating gases, and explosive gases; although there were gases which may be grouped under two of these headings. Among the toxic gases they found ammonia, arising from freezing mixtures; benzol, coming from vehicles, garages and depots; carbon monoxide, a product of illuminating gas, products of combustion, and flue gas; petrol, from vehicles and depots; sulphured hydrogen from coal gas and sewer gas; and sulphur dioxide from the fusing of insulators. Among the asphyxiating gases they found carbon dioxide, a product of combustion and a sewer gas; nitrogen, of similar origin; and natural gases. Among the explosive gases were benzoës; carbon monoxide; ethane; petrol; hydrogen; and methane in natural gases and sewer gas. The gases identified in these tunnels most frequently arose from illuminating gas, natural and artificial.

Natural gases, used a good deal in the United States, are not as a rule toxic; but they only need a small quantity of artificial gas, with its content of carbon monoxide, added to make them dangerous.

Statistics

Two fatal cases of poisoning by sulphured hydrogen were reported in the U.S.S.R. by Litkens in 1927, who found, in sewers 0.31, 0.575 and 1.09 per thousand of toxic gas, according to where each sample was taken.

Data relating to sickness and mortality among the sewer-men of Paris were collected by Hein de Balzac, Agasse-Laforest and Feil in 1926. Their observations scarcely justify any decision as to establishing a connection between illness and occupation or not. Absence through sickness was twice as much in duration as absence through accidents, amounting, on an average, to four days a year per head. The principal causes of illness were chest troubles, digestive disturbances, rheumatism and cardiac pains. Four per cent. of accidents due to falling into water were reported; jaundice, 6 cases; conjunctivitis, 2; no rat bites occurred, but, strangely enough, cat and dog bites.

The death rate for the period 1900-1924 fell from 3.2 to 1.7 per cent.; invalidity at the end of the twenty-five years had risen from 1.1 to 6 per cent. The improvement in the mortality rate is attributed to the adoption of a working day of eight hours, to measures of individual cleanliness, with lavatories for washing and cloakrooms, since 1910, and to higher wages, which allowed a higher standard of life.

In a list of causes of death are found: 7 cases of chronic respiratory diseases, bronchitis and tuberculosis; 1 of tuberculosis of the vertebral column; 1 of asectis; 3 of external diseases; 3 accidents, and 3 not specified. Another list, for 1925-1925, gives, out of a total of 85 deaths, the following causes of death: 27 cases of pulmonary tuberculosis; 8 of respiratory diseases; 2 of poisoning by sulphured hydrogen from residuary water; and 2 accidents due to asphyxiation in the sewers. As regards invalidity in 1925, 3 cases of rheumatism were reported, 2 of chronic respiratory diseases, 1 of pulmonary tuberculosis, 1 of chronic gastritis, 1 nervous disorder, 7 accidents and 12 not specified. 1

In the U.S.S.R., Zatzepine in 1929 studied ocular diseases among well-sinkers of the Don. These men remove mud and slime from the bed of the Don by dredging. This writer found 385 cases of various ocular disorders among the 315 workers examined; 264 had conjunctivitis, which he attributed to the inadequacy of the artificial light provided and to dust. In practice the mud and slime taken out is spread on the dredgers and so is reduced to fine dust, which may be the cause of this ocular trouble. It should be added that the conditions of housekeeping on the barges on which these men live are not good, and ought to be improved.

Another enquiry, in 1927, was concerned with the conditions of work of men

1 See also the report published in 1938 by Etienne Martin (Lyons).
employed in repairing aqueducts at Moscow. This work is carried on largely in observation wells at a depth of from 3 to 3.5 metres, with a cubic space varying from 2.5 to 10 metres. In order to go down into these wells, the diameter of which only measures 70 cm., the men are obliged to remove their upper garments.

Analyses made from time to time of the air in some wells at the level at which the man was breathing gave the following results: carbon monoxide: 1.2 to 3.5 mg. per cub. metre of air; carbon dioxide: from 49.8 to 533 mg. The workmen often complained of headaches, giddiness, buzzing in the ears, stiffness, insomnia, and troubled vision.

**Navvies and Road-Men**

The construction and maintenance of roads are distinguished technically from each other as two separate processes, especially as regards country roads.

The ordinary process is called "macadam"; it may be done with or without rolling, or with rolling and superficial tarring; it consists in spreading such stones as broken flints or gravel on the level where the road is being constructed, either with or without foundations, and then covering the stones, in order to fill in all the empty spaces, with finer material to bind and hold them together. This material is composed of gravel, coarse sand and bitumen or asphalt. After tarring, a steam roller is used.

Roughly speaking, the various kinds of tar used for roads may be grouped as follows: tar for surface treatment; tar for internal treatment, and, in a mixture, as "tar macadam"; tar with anthracene oil, 50/50 and 60/40, is used for surface treatment; 65/35 and 70/30 for internal treatment.

Practically speaking there are many varieties, to which concrete and tar cement must be added.

Tar or special mixtures are also applied in liquid form to road surfaces by spraying machines. The products are melted in a little boiler by the roadside. When the tarring is of some depth, that is to say, when the mixture of stones, sand, and binding bituminous or asphaltic substances, is spread on the road and crushed down by a roller, the result is designated as "tar macadam", or macadam made with tar.

In towns, considerable use is also made of special blocks of wood, which, after being laid, are steeped and sprayed with asphaltic substances.

This brief summary of the two principal processes suffices for the present purpose.

Certain occupational etiological factors are common to the town labourers, who constitute the urban body of road workers, and to the country labourers or road-men; whereas other factors are peculiar to one or the other group.

All those who are employed in the transport of material for repairing the roads, and in the transport of rubbish, are designated by Pieraccini under the generic name of "para-stradini" (para-road-men). As in the case of very many other road workers, such as paviors, stone-breakers, masons and labourers, these men are exposed to the inhalation of hard mineral dust, and their work is very strenuous.

The operations connected with treating the surfaces with tar, bitumen or asphalt expose the workers to the inhalation of ammoniacal and, especially, sulphurous fumes from these various substances, as well as of dusts which arise from the material once it is dry and mixed with the dust of the road. The tar is always melted by the roadside, and it often happens that petrol and heavy oils are added to make the tar melt more easily. The worker is then exposed to irritation of the upper respiratory tracts and to conjunctivitis. This danger is repeated, on a less serious scale, during the work of spreading the hot tar or similar substances on the surface of the roads.

The dangers which may arise from tarring roads have long been a matter of discussion, the chief danger appearing to be that of pulmonary cancer. It must be acknowledged, however, that this opinion is not upheld in scientific circles, and that as recently as 1930 Lehmann expressed the view that tarred roads are not injurious, and that pulmonary cancer, which some people have tried to connect with tarred roads, is certainly not caused by the tar.

While refraining from forming any decision on this still obscure question, it will be sufficient to refer to it here and to express the hope that successive observations may make it possible in the near future to form a more definite opinion, based on convincing evidence.

When roads are constructed by excavation, or where they are shut in between houses, the air is thick with dust raised by vehicles; it is also laden with tar fumes, or even with such exhaust gases from motors as carbon monoxide, or lead due to the use of ethyl petrol. Much has been written on this subject, and several experts consider that it is quite possible that poisoning may be caused by exhaust.
gases from motors on the big arterial roads of towns where motor traffic is considerable.

The different noxious factors just referred to may also be found arising from work on country roads, but they are less frequent and only occur under certain well-defined circumstances, e.g. work along the side of conduits, open trenches, or liquid manure trenches, since closed sewers and pipe-lines are unusual in the country.

Men employed in supervising and maintaining great main roads represent a very extensive group of workers, as the road system is daily assuming increased importance in every country.

Road-men are compelled to work and live most of the year in an atmosphere laden with dust. This dust is raised into the air when roads are swept, and dust is shovelled up by the rapid transit of motors and lorries, and even by the wind, which, however, by dispersing the road dust, protects the road-men to a certain extent. The material upon which these men work is dusty during several months of the year; though, of course, it varies according to its geological nature, to the exposure, latitude, and altitude; it is dustier during cold and damp or semi-liquid during the other months.

All this work has to be carried on in the open air, in the country, on plains or on mountain sides; consequently the workers are exposed to every atmospheric vicissitude, from extreme heat to extreme cold.

Cold and damp are common causes of rheumatism; they affect the respiratory organs in particular, and accentuate the habitual inhalation of dust. Hence arises a high death-rate from acute and chronic forms of broncho-pneumonia.

For the work of breaking up pavements, compressed air tools are often used; for this reason there occurs an unusual incidence of the troubles due to these tools (see article "Pneumatic Tools"). For concrete workers on motor roads, see article "Cements".

**Statistics**

Statistical facts referring to the health of road-men on the system of highways are limited to those published by Pieraccini in 1928, which deal with road-men in the province of Florence, and cover a period of seven years, from 1918 to 1925. The average length of life was fifty-seven years, and the average length of service twenty-six years. It should be noted that the personnel concerned were engaged at between the ages of twenty and thirty years, after medical examination; thus they may be described as picked men. The death-rate was as high as 8.72 per cent.; pulmonary tuberculosis accounted for 38.8 per cent. of the deaths, and for 77.7 per cent. of all other acute and chronic respiratory affections. The statistics do not give any information as to other causes of death, such as rheumatism, sunstroke, or cold.

**Pathology**

Removing snow and ice with a broom or a shovel or with a pick is a dangerous, unhealthy and exhausting operation, for it is carried out at a low temperature, often accompanied by damp, and often hazardous, due to falls and slipping, while it favours eye troubles.

Road-men, obliged to go some distance over a frozen or snow-covered road for inspection or snow-sweeping, are exposed to the reflection of solar rays from the white surface, as well as to the action of road dust and wind; hence arises acute irritation of the eyelids and conjunctiva, with watering of the eyes and sometimes photophobia, sub-conjunctival ecchymoses and superficial ulcerations of the cornea. This "snow opthalmia," is observed, although rarely, among road-men; thus Oblath quotes an epidemic among the workers on the roads in the Caucasus, as described by Reich. Generally it is temporary and is easily cured. The experts even recognise that there may be an individual predisposition to this ocular lesion.

In summer, road-men are exposed, particularly in some countries, to heatstroke and sunstroke, and to the action of light rays. The prolonged action of sun glare, in a dry atmosphere, with reflection of heat from the surface of the road, or the heap of stones, when stone breaking, plays an important part, according to certain medical authorities, in the production of opacity of the lens.

Other medical men are more cautious in their statements; and others again consider that excessive strain and abundant perspiration may possibly be connected with this formation of cataract which, in their opinion, resembles the cataract found among workers who are exposed to radiant heat from furnaces.

Dust from the roads, in hot countries, mingles with sweat and cutaneous grease, and forms a layer irritating to the skin, without causing real dermatitis, but just erythema on the face and arms, due to solar rays. As has been previously remarked, cases of subacute or mild
ciliary blepharitis are also found. The movement of the eyelids cleans the surface of the eye and the tears remove the dust and pass it into the nasal ducts. It appears to be the irritating action of this dust on the lachrymal passages which encourages the development of dacrty-cystitis in the case of workers who are employed on dusty operations. However, mineral and insoluble dust from roads — for it is unusual for road dust to be mixed with dust that is soluble and exerting a chemical action — ends by irritating the conjunctiva and causing inflammatory and catarrhal affections, which follow a favourable course, if the workers give up the dusty occupation. In the case of workers habitually exposed to dust and wind, chronic blepharitis and conjunctivitis occur. Here also individual predisposition plays an important part (Oblath). Gallenga has observed cases of pterygium, even in the case of young workers; this illness is found more rarely among other groups of workers, and in higher social classes, and Landshere has considered it to be an occupational disease, confirming the opinion of Fuchs, who maintained that these conjunctival changes are due to the action of dust and inclement weather.

The continuous action of dust is responsible for little opaque patches and small incrustations on the cornea, which have affected the sight; dust blown into the eyes by wind and storm causes a permanent feeling of having a foreign body in the eye causing these workers to rub their eyes, and bathe them with water.

**Stone-Breakers**

When studying the conditions of road workers, the work done by stone-breakers deserves special attention. The breaking of stones and pebbles, ready for road-metal or for use in macadamising, is an operation carried on almost entirely by the roadside, during the various months of the year, according to country and season. Although stones nowadays are broken up mechanically, in crushing machines with rollers or jaws, the custom of breaking them by hand is still very common. The largest stones, weighing several pounds, are broken by means of an iron sledge-hammer from 4 to 5 kg. in weight, and then smashed with a smaller iron hammer of about a pound. Road engineers recommend the selection of large stones and pebbles, as smaller ones give a product of inferior quality.

The stone-breaker may work standing or in certain countries seated on a low seat, which not infrequently is placed on the heap of stones. The work is tiring, and demands the cooperation of the muscles of the trunk, and especially of the muscles of the upper limbs.

When it is remembered that stone-breaking is a dusty operation; that the stones lie in dust or mud; that dust is continually raised during the manipulation of the stones; that the road itself is very dusty; that the stone-breakers work by the side of the road during the months when dry debris exists in large amounts; that in the seated position the distance between the nose and mouth and the level of the road is about 3 ft.; that breathing is quick and deep, sometimes through the mouth rather than through the nose; consideration of all these factors justify the conclusion that stone-breakers must inhale and swallow large quantities of dust. This explains why dust is found in the faeces of these workers.

The palm of the hand, especially the palm of the more active hand, has a permanent exaggeration of the hollow, and the four fingers are partly flexed. In the case of aged stone-breakers, the limited extension of the hand is probably due to a retraction of the tendons, consequent upon prolonged and enforced flexion, in the course of work and continuous handling of hard bodies. This lesion has also been observed in other workers who have to use heavy and rough tools (Mori). The skin of their hands is coarse, wrinkled and thickened, and, in the horny palm of the right hand, ridges of skin that are even harder stand out along the metacarpophalangian line. In the left hand, the callosity is more uniform; and, in addition, the edge of the nails is worn from continuous contact with the rough surface of the stones which the man has to place under the hammer.

The specific accidents that injure the stone-breaker are crushings of fingers, and especially the ends of the fingers, which happen frequently. Another and more serious traumatic lesion, and one that is not rare, affects the various parts of the eye; it comprises lesions caused by splinters from the stones, which cause bruises or wounds, or become imbedded in the tissue. As a rule, medical aid is only invoked in the case of serious eye injuries. The stone-breakers of the province of Florence, about 150 in number, experience an annual average of 15 serious eye wounds.
entirely suppress fatigue for the workers, and to shorten the time taken in the operations. This work is often carried out far away from the road, which ensures an atmosphere free of dust for the workers.

Where mechanical means cannot be adopted, it is advisable for the stone-breakers to work at some distance away from the roadside, where they are away from dust; they can afterwards convey the stones to the various points on the road where work is in operation.

Stone-breakers should be provided with goggles to protect them from splinters and sun glare in the summer, as well as with thick fabric gloves to protect their hands.

It would be wise to regulate the working hours of these men, who generally work on piece rates, and to exclude children from this work.

In sewers and conduit tunnels, workmen should be provided with safety lamps for detecting the presence of toxic gas. These tunnels should also be ventilated, and the air maintained fit for the men to breathe. The tunnels can quite easily be made healthy by means of apparatus fixed in the road, which withdraws the foul air from the tunnels and introduces fresh air.

The French Ministry of Labour issued instructions to Prefects on 22 June 1925 referring to the establishment and permanent control of purifying septic tanks and similar contrivances, in accordance with a report laid before the Higher Council of Public Health, drawn up by a special committee (Calmette and Roland).

In Belgium, a committee of enquiry set up on 28 March 1927, on first aid and care in cases of asphyxiation during the laying down of gas pipes, made a special study of construction and earth works, as well as the sewer system, at which the workers are exposed to special health risks and sometimes to fatal asphyxiation.

In Bulgaria conjunctivitis caused by ammonia and sulphuretted hydrogen is compensated as an accident; in Mexico compensation is afforded for injury sustained by sewer-men, workers emptying and cleaning cesspools when such injury is due to carbon dioxide and sulphuretted hydrogen.

Prof. G. Pieraccini
(Florence).
Schoolteachers


The staff in schools, and teachers in particular, are liable to fall victims to certain diseases in regard to which prophylaxis and treatment are of capital importance with a view not only to protecting the occupational class in question, but also on account of the numerous children exposed to possible contagion.

Pathological manifestations met with amongst teachers are caused and sustained by various factors such as bad hygienic conditions under which the teacher is not infrequently called on to carry out his work; the sedentary life; the physical resistance of the individual and predisposing him to various diseases (nutritional disturbances, tuberculosis, nervous exhaustion, etc.).

**Statistics**

A very extensive study of morbidity amongst teachers is that of J. Y. Hart, which deals with the staffs of elementary schools in London for the fifteen-year period from 1904 to 1919. Expressed as a percentage based on the working days lost during the year, the incidence of the various diseases met with may be shown as follows:

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Entire teaching staff</th>
<th>Complete period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before the war</td>
<td>During the war</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory diseases, colds, influenza</td>
<td>43.2</td>
<td>43.0</td>
</tr>
<tr>
<td>Nervous and mental diseases</td>
<td>16.8</td>
<td>18.7</td>
</tr>
<tr>
<td>Diseases of the digestive system</td>
<td>8.4</td>
<td>7.4</td>
</tr>
<tr>
<td>Forms of rheumatism and spondritis</td>
<td>6.0</td>
<td>5.1</td>
</tr>
<tr>
<td>Infectious diseases</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Debility and anaemia</td>
<td>3.7</td>
<td>3.6</td>
</tr>
<tr>
<td>Surgical operations</td>
<td>4.2</td>
<td>4.1</td>
</tr>
<tr>
<td>Diseases of the heart</td>
<td>1.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Diseases of the eyes</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Diseases of the teeth</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Menopause and women's diseases</td>
<td>1.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Accidents</td>
<td>3.7</td>
<td>3.2</td>
</tr>
</tbody>
</table>

This enquiry covered a total of about 14,000 individuals at the beginning, and 20,000 towards the end, in the proportion of 30 men to 50 unmarried and 30 married women.

Analysis of the morbidity statistics classified per annum, per age-group and per circumstances (marriage, post held, status, assistants, etc.) has led the investigator to conclude that sex plays a fairly important role in the pathology of teachers.

The average sickness rate for the male sex was 4.6 per cent. per annum, whilst that for unmarried women reached the figure of 8.2 per cent. and for married women, 9.3 per cent. These figures do not take into account absence connected with childbirth.

Age shows an influence on the duration of periods of sickness, especially in the case of the women. Amongst the men, the average duration, which was 4.3 days for the age-group 21-25 years, attained 9.2 days for the group 61-65 years. The corresponding figures for the unmarried women were 6.4 and 19.1, and for the married women, 11.1 and 19.6. For the men, the most healthy period was between thirty and forty years of age, morbidity falling to 2.8 days per annum, whilst for the married women it was between thirty-one and thirty-five, with a morbidity rate of 7.1 per annum. As regards the unmarried women, the morbidity increases yearly up to the age of fifty-five, where it attains 50.1 days per annum. After this period, it drops to 10.4, with a new increase between the ages of sixty-one and sixty-five.

The most frequent affections are those of the respiratory organs (bronchial tubes, throat and forms of influenza), constituting 43 per cent. of the total morbidity. Nervous and mental troubles take second place (16 per cent.), followed by gastric troubles (8 per cent.), forms of rheumatism (5.6 per cent.), infectious diseases (3.8 per cent.), debility and anaemia (3.7 per cent.).

About 88 per cent. of the absences were incurred by a small percentage of the persons under observation (21 per cent.), and the average duration of sickness was eight days. The absence record is not so heavy as would appear, by reason of the fact that 43 per cent. of the total absences were due to a restricted number of teachers, 3 per cent. only of whom were affected with illness having a duration upwards of fifty days. During the war, periods of absence on account of disease increased by 37 per cent.

Other English statistics drawn up by Fairfield affected 13,748 teachers under observation during a period of twelve economic circumstances, often resulting in overwork (necessity for supplementing the salary earned), insufficient nourishment — all causes capable of reducing the physical resistance of the individual and predisposing him to various diseases (nutritional disturbances, tuberculosis, nervous exhaustion, etc.).
years, and revealed the fact that the great majority of pathological troubles meet with amongst the women were of a nervous order (225), and came under the category of psychogenic syndromes (224). Leaving out of account cases of influenza (84), digestive disorders (86) are partially at least overshadowed by the incidence of affections of an oto-rhino- laryngological order (68). Finally, in order of importance, there come gynaecological forms of disease (66), circulatory affections (56), accidents (49), rheumatism (37), etc.

In Bulgaria, Petroff has furnished a report (1910) on the health of teachers, utilising data collected by the Medical Inspector, V. Georgief. The returns cover 8,306 teachers, 3,650 being women observed during a period of one year. The 675 medical certificates, 500 of which apply to women, showed the following distribution: infectious diseases, 157 (123 women); nervous, 72 (39 women); respiratory, 78 (51); circulatory, 23 (20); sense organs, 9 (5); digestion, 62 (44); genito-urinary system, 93 (72); skin, 11 (5); various, 17 (10). Childbirth and its sequela show the figure 183.

In Italy, E. Sorrentini has furnished very detailed data in regard to morbidity amongst teachers in elementary schools.

The enquiry covered 677 teachers, of whom 1,461 were women, classified according to age, as follows: 20-30 years, 152; 30-40 years, 253; 40-50 years, 226; 50-60 years, 132; 60-70 years, 33; above that age, 1; no age stated, 50.

According to this enquiry, respiratory affections occupied the foremost place, the most frequent clinical forms being recurring bronchitis, laryngitis and pharyngitis. Amongst the infectious diseases, intestinal affections predominated. Finally, nervous diseases due to a constant expenditure of nervous energy and diseases of the digestive system due to unhealthy nourishment and irregularly regulated digestion occupied the third and fourth place respectively.

The enquiry revealed the limited number of children in teachers' families. The figure 0.9 out of 100 families was below the average (4.26), and even below that for various adjacent professional classes. On the other hand cases of abortion were found in excess, the percentage being 18.28. Finally, there was revealed a considerable infant mortality, represented by 43.03 per cent., a figure which exceeds the rate met with amongst the poorest classes. Amongst the most frequent causes of infant mortality, after respiratory diseases came forms of acute infection, the contagion being facilitated by the parents. Diseases of a digestive order figure last on the list.

During the scholastic year 1921-1922, only 17 per cent. of teachers in Milan (354 out of 1,990) had no absence due to sickness, whilst for the year 1917-1918, 1,269 male and female teachers had 27,374 days of absence, and in 1921-1922, 1,626 had 29,444 days of absence. On an average, the men showed a rate of 12 absences, the unmarried women 19, and the married women 23.
portion of 15 per cent. of the deaths from all causes, pneumonia 5.6 per cent., other respiratory affections 1.7 per cent., cardiac affections 12.6 per cent., diseases of the respiratory system 4 per cent., etc.

For female teachers, the values were higher. There were found, for example, 38.7 per cent. due to pulmonary tuberculosis for the age-group 25-34 years, and 10.2 per cent. for the group 35-44 years. Cancer accounted for 4.8 per cent., in the group 25-34, 13.9 per cent. in the group 35-44, 22.2 per cent. in the group 45-54, and 16.2 per cent. in the group 55-64.

Amongst cases of sickness affecting 675 Bulgarian teachers (see above), the number of deaths only amounted to 34, due on 17 occasions to pulmonary tuberculosis (7 cases being women); on 2 occasions to typhoid (one woman); on 5 occasions to pneumonia (2 women); 2 occasions appendicitis (1 woman); 1 cancer; 1 general paralysis; 1 sclerosis of the liver; 2 circulatory diseases (both women), and on 5 occasions various diseases (3 women).

Italian statistics covering the decennial period from 1907 to 1916 show evidence of a fairly high mortality amongst teachers and professors in comparison with the general mortality. The male teaching staff comprised about 35,000 persons. The general mortality amounted to about 19 to 25 per thousand, as against 16.47 for males of fifteen years and over, respiratory diseases showed a figure of 3.42 (2.75 per 1,000), disease of the urinary system 1.06 (0.45), etc.

In 1917, the mortality for the same occupational group was 23.7 per thousand as against a general mortality of 16.87. It is believed, moreover, that mortality amongst female teachers is about one-third higher than that for male teachers. This higher mortality rate is the logical consequence of a higher morbidity rate.

According to the mortality statistics of the Registrar-General of England and Wales for 1901-1903, male teachers showed fairly favourable comparative mortality figures — a little less so for the age group 16-25 years. For the later age-groups, the mortality rates did not exceed the comparative mortality figures, except for appendicitis, diabetes and influenza.

While Italian statistics available would appear to prove that the data in regard to women reveal similar results, in Great Britain the mortality rate for female teachers was, in 1925, 0.55 as against 0.44 per cent. for male teachers (Fairfield).

PATHOLOGY

Pathology as it affects teachers is therefore characterised by particular frequent occurrence of disease forms, notably respiratory affections, nervous affections and infectious diseases.

Amongst respiratory affections, pulmonary tuberculosis occupies first place. Whilst in France Roblot (1925) only found 2.75 per cent. of confirmed tubercular cases amongst members of the French Association of Teachers, Leune found a higher figure (4 per cent.) amongst those of the Département of the Seine, and Nobécourt met with the figure 5.77 amongst pupils in the higher Normal schools.

Th. Altschul, of Prague, reported in 1913 the mortality from tuberculosis of 5.83 for men and 14.35 for women, whilst in Bohemia during eight months he found only a figure of 1.5 per thousand. Schmidt, of Düsseldorf, found tuberculosis to amount to 13.3 per cent. as a cause of retirement or of death amongst 172 teachers, 22 of whom were women. Other statistics, covering 2,790 deaths, showed 18.3 cases of tuberculosis per thousand.

The enquiry effected by Frederick Lorentz (1913) dealt with male members of the German Teachers' Fund, of Berlin and showed, for the period 1907 to 1912, 247 cases of tuberculosis in 2,167 deaths. The mortality rate was said to be, according to this enquiry, parallel to the social position of the teacher, and higher in the country than in the town, and higher also amongst teachers in primary schools than amongst those in higher schools.

As regards the age, death occurred more frequently amongst the group 25-30 years. The mortality curve attains its maximum at the age of twenty-eight, to drop again at the age of thirty-three, remount at thirty-four, and descend once again regularly, except for 2 points at forty-five to fifty years of age. Between twenty-five and thirty-five the number of deaths comprised about 50 per cent. of the total fatal cases.

According to statistics in the United States for 1909, pulmonary tuberculosis amongst teachers exceeded the average for the age-group 25-35 years, and likewise in Sweden.

Hubbert, Todds, Oldright, Lustig, and others have drawn attention to the high incidence of pulmonary tuberculosis and in particular of a special form of laryngitis amongst teachers. These authorities consider that laryngitis, due to exhaustion of the organs by abuse, may be considered more than any other disease, as the occupational malady of teachers. Contributory causes of this lesion are to be attributed to age, which brings about changes in the voice, to an individual nervous constitution, to under-nourishment and
— amongst men — to the abuse of alcohol and tobacco. There have similarly been blamed sudden changes of temperature favouring congestion of the larynx, and serving, as a starting point, for endemic affections of the organs of speech.

Rarely secondary to affections such as emphysema, asthma, adhesions of the pleura, vegetations, adenoids, hypertrophic rhinitis, laryngitis is the result of the vocal effort demanded of the teacher, who is obliged to teach in a functional disorder. As is known, over-crowded classrooms. Alterations of the vocal cords finally become transformed into extinction of the voice or transient hoarseness into chronic laryngitis, with the result that on the larynx — locus minoris resistentiae — certain affections are apt to settle — larynx, cancer, and especially tuberculosis.

It is evident that laryngeal affections, symptomatic of other disease forms, become aggravated by the continual exercise of the voice in the case of teachers. Diseases of the nervous system — functional nervous affections — are those which are most frequently met with amongst teachers, organic affections being more or less rare. Even where such exist, they possess no special character justifying their consideration as specific troubles connected with the occupation. As regards functional disorders, it is known that the troubles in question are psychic-genic syndromes, the origin of which is generally to be found in the moral atmosphere in which the teacher is called on to exercise his profession. Amongst the women, nervous troubles would not appear in direct relation to the menopause. In fact, there have been reported cases of neurosis and psycho-neurosis at twenty years of age (42 cases), at thirty (56 cases), between forty and forty-four (30 cases, one case of menopause), between forty-five and forty-nine years (53 cases, and 2 of menopause), between fifty and fifty-four (31 cases, and 6 of menopause), between fifty-five and fifty-nine (31 cases, and I of menopause). Amongst the troubles described as of a nervous character, the ones most frequently noticed are carbon monoxide poisoning, which occur with a fair amount of frequency when the heating system is defective. The same cause may engender predisposition to miscarriage (Agasse-Lafont).

Epidemic contagious diseases occurring with frequency among the scholastic population may also constitute a danger for the health of teachers. While, thanks to acquired immunity, risk of contagion, notably in the case of eruptive diseases of childhood, is reduced, infectious diseases are shown to be amongst the most frequent pathological troubles in certain statistical returns affecting teachers. On the other hand, the teacher may play the part of a carrier and, by his intermediary, communicate such diseases to other persons, notably members of his family.

Apart from the three categories of disease mentioned, there have been met with amongst teachers gastro-intestinal and cardiac troubles, to which attention has been drawn on account of the relatively important place which they occupy in statistical returns.

Hygiene

Amongst causes favouring disease amongst teachers a foremost place is due to the conditions in which they are called on to effect their work: indoor life in classrooms, sometimes in a very dusty and vitiated atmosphere, lack of cleanliness, and in particular overcrowded classes requiring a continuous effort of the vocal organs. Attempt should therefore be made to combat these defects, to create comfortable classrooms adequately furnished and suited to the requirements of modern scholastic hygiene. In order to combat the monotony of the sedentary life the schoolmaster should take an active part in the recreational pursuits of his scholars. Thereby he will improve his physical health and also his moral tone and be enabled to establish intimate relations with his pupils, becoming for them a great friend as well as a master.

In order to avoid the risk of infectious diseases a working uniform resembling the doctor's overall, should be worn during class hours and removed on leaving the school (Méry and Genevrier).

Once he has been attacked by disease the teacher should of course follow the requisite treatment. Particular attention should be accorded to tuberculosis, which constitutes a permanent risk for pupils. It has been proposed that teachers should be medically examined periodically in order to detect incipient cases and prevent infection at a stage when it is also important to commence treatment under the best conditions for its efficacy. Attention should be paid to hygiene in the classrooms, enlightening social organisation of the professional life of teachers, avoidance of harmful effort and over-strain, careful vocational guidance prior to the choice of the career,
SCHOOLTEACHERS

with contra-indication as to the profession for all those who are weakly.

In France, when a tubercular teacher is unable to continue his work and is obliged to follow a treatment which, if not very costly, at least demands material resources already severely strained by inactivity, there is granted long leave with full pay during three years, and half pay during two years, with renewal each half year (Even Act). It would appear, however, that the application of these measures has given rise to certain difficulties in the absence of means permitting detection not only of suspected cases but also of confirmed cases (Parisot and Viollette). In order to remedy this state of matters the French Congress of Hygiene (1921) passed a resolution to the effect that the presence of any tuberculosis, whether open or in process of evolution or latent, should entitle teachers to leave; that all male and female teachers and auxiliary staff should be annually subjected to specialised medical examination, generally at dispensary of social hygiene with the assistance of all means of diagnosis at present available; and in particular that those already attacked should be submitted to examination for as long a period and as repeatedly as necessary.

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In Japan the prefectorial Governments allocate sums of money to teachers in primary schools who have to leave the service on account of contagious disease (tuberculosis, leprosy, etc.). A law (1914) and a Regulation issued by the Department of Public Instruction (1915) established the procedure to be followed in these cases. From 1916 to 1925 there has been indeed constant decrease of tuberculosis and of the assistance requiring to be granted to teachers suffering from this disease (693 persons were accorded assistance and 145,985 yen were paid in 1916; 381 received assistance and 84,034 yen were paid in 1925). As regards prophylaxis in relation to derangement of the vocal organs and affections of the larynx, hygienic precepts ought in general to be observed in regard to voice production: rest whenever strain or complications develop as regards the voice, regulating the lute of the voice, good articulation, rhythm of speech, posture (head well up, chest free, etc.), elimination of all factors imposing an undue great effort on the voice, a reduction of the number of pupils in the classes, good acoustics in the classrooms, exclusion of toxic factors such as tobacco, etc.

Systems of heating ought to be specially supervised. Teachers should be made aware of the danger of carbon monoxide poisoning and informed of the early symptoms in order to be in a position to detect these either amongst their pupils or in their own case (Agasse-Lafont).

The campaign against nervous derangements is highly important not only in regard to the protection of the patient's health but also as regards the moral and intellectual well-being of the scholars. Rigorous vocational guidance should be practised with a view to eliminating from Normal schools all subjects predisposed to affections of the nervous system, and particular attention should be paid to personal hygiene, physical as well as moral, and the teacher should fortify his mind with humanitarian and moral culture in order to prevent depression due to moral conflicts and unforeseen events liable to upset the equilibrium of the inexperienced teacher.

While in account of certain of the above conditions the teaching profession may be considered as a difficult career, it possesses the great advantage of long annual holidays. This period of rest should be utilised by the teacher with a view to developing his physical activity, and wherever possible he should profit by the opportunity for leading an open-air life (country), in practising sport which is not unduly strenuous, for instance walking, rowing, swimming, etc. He will thus achieve alternation of physical habits providing the best guarantee for conserving his health and combating pathological manifestations arising out of the professional life which he is obliged to lead, during periods of scholastic inactivity.

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Scientific Management and the Human Factor

Just as the engineer studies the output of the machinery, endeavours to increase its productive power without injuring its lasting powers and endeavours to use it in the most economical way, so the physiologist, regarding man as a machine sui generis, tries to increase his output without tiring him out and having regard to the greatest economy in working. The object of industrial physiology is to organise work in greatest harmony with man's functional power.

The scientific aspect of human work has for long occupied man's thoughts. To go back only to the seventeenth century it may be recalled that Galileo (1644) had the curiosity to apply his studies on the principles of simple machines to the human frame. Towards the end of the same century, Sauveur, Philippe de la Hure and Amontons took up the study of the human machine, notably as to the relation of force and physical weight, and on the carrying of loads. La Hure it was who fixed on 65 kg. as the upper limit for the carrying of loads, although he would allow 75 kg. for loads carried on the shoulder or in walking along a level road. Amontons interested himself especially in the rapidity of the rhythm of work with the object of determining quantitatively the daily task of the worker. Vauban dealt rather with the question of supervision, which he regarded as a means of increasing production. In his ground-levelling operations he came to the conclusion that output stands in direct relation to the load carried by the workman and the distance he has to traverse. De Carus (1729) wrote a popular work entitled "Traité des forces mouvantes" for the use of workmen and of his contemporaries. Bélidor (1729) continued the work of Vauban; he expressed in the following words his own ideas as to length of hours and wages: "It is certain that ten hours a day for a man who has his own interests to consider is equal to fifteen in another who has his hours regulated for him. To push men further is to cause overstrain and to expose them to illness and fatigue."

The eighteenth century was the epoch of Lavoisier. It was further enriched by the researches of Coulomb (1736-1806) on the "Force of Man", in the course of which he discussed work in injurious trades, weight carrying, manipulation of windlasses, cranks, etc. Coulomb was aware of "the method of alternative short spells — of carrying loads with intervals of rest as being the best for the animal economy". It was he who first stated that output "varies with the skill, selection of the individual, and food", and took account of the factor of psychology in his investigations. He recommended that a good workman on piece work should be kept under observation, but at the same time, so as not to affect the immediate job in hand, should not know that he was being watched.

In the nineteenth century Dupin and Poncelet undertook a campaign in favour of the distribution of scientific and professional knowledge among workpeople. Finally the researches of Chauveau, Atwater, Moaso, de Saussure, Rubner, Zuntz, Dubois, Reymond, Loewy, Marey, Braune, Fischer, Demeny, Liesse, Claude Bernard, Humbert, Imbert, Jantier, Durig, Amas, Maggiora, Hertlitza, Atzler, Catcart, etc., are too near our own time for all not to be acquainted with their work. They relate mainly to laboratory research, the practical application of which up till now has not been very great. Economists have likewise devoted their attention to the problems of the scientific organisation of industry. Thus, Adam Smith interested himself in the division of work and gave consideration to the economy of effort and to the technical division of work. He was followed by Babbage and J. Stuart Mill in Great Britain, by J. B. Say, Garnier, and Clement in France, Walker in America, and by Von Hermann, Cohn, Brentano, and Abbé in Germany. Societies commenced to interest themselves in these problems,
thus it was that towards 1910 the German Society for Social Politics started an enquiry into the subject of vocational selection, the nature of the occupation, the importance of work in modern industry, etc.

The distinction between what is called scientific management and what is meant, on the other hand, by the physiological organisation of labour is of importance.

By scientific management is generally meant the method thought out and developed by the American engineer W. Taylor, the principal lines of which it is proposed to describe here.

"Taylorism" has not the same object in view as industrial physiology; increase in production is sought by the one and increase of human output by the other. These objects are not opposed to one another; the task of the science of the future and of industrial physiology, indeed, will be to co-ordinate them into a single system.

Scientific management is a very big thing including financial, technical and social questions. Industrial physiology on the other hand has a more limited field; it only takes up one side of the problem and supplies scientific management with information suitable to a general solution.

**THE BASIS OF TAYLORISM**

The problem set by Taylor is as follows: to find the conditions of work which will enable a workman to perform a maximum amount of work with a minimum of fatigue, that is, to apply to the machinery and the man the formidable economic law of how to obtain the maximum effect with the minimum effort. For this it is necessary:

(a) to alter the machinery — a technical expert would be useful here whose duty it would be to study the changes necessary in the plant, having always in mind technical progress;

(b) to select the workers — dismissal consequent of those who after a certain length of time are considered to be incapable of furnishing the prescribed output;

(c) to reduce the operation to its simplest terms — that is to say, split it up into the simple elements of which it consists, and, with the aid of a chronometer, choose the method which accomplishes it most rapidly in order to suppress all unnecessary useless movements;

(d) to instruct the workmen — when after long tests and theoretical calculations, the best technique for the job in question has been arrived at, it is taken as the standard to be taught to, and learnt by, all the workpeople;

(e) having clearly defined the job, to give incentives in the shape of prizes to those who deserve them; most (a special office has the task of fixing each time the prescribed daily output and the prize is awarded to those who attain it).

Such are the principal laws of Taylor's method. It would be hyperbolic to describe it as "scientific"; "rational" would be more exact.

This method, provided that it is linked up with wise collaboration on the part of the workers on the one hand and of the management on the other, does admit of the output of an industry being brought to its maximum.

**Physiological Criticism of Taylorism**

Taylor's system, looked at from an industrial point of view, certainly succeeds in increasing production, as has been empirically demonstrated by the industries that have adopted it. But looked at from a biological standpoint it would appear inadequate in many respects.

(a) **Rigidity of the Method**

If, theoretically, a perfect adaptation of man to his occupation and an extreme diversity of the means of work are admitted in practice, it is difficult to have an installation of machinery sufficiently varied and a sufficiency of manual labour to apply the system rigorously. Consequently a compromise has to be made in regard to the selection of workers unless a large number of men are to be dismissed. Many, indeed, are dismissed who with will, application and patience, in virtue of latent human energy, might become in time very capable workmen. This is why recourse is had to practical rather than to physiological and psychological tests. But a careful and stringent selection, it is evident, is needed both in the interests of industry and of the workman.

(b) **Automatism of the Workman**

By Taylor's system the workman is turned into a mechanical unit, which effects its work just like the running of a machine. That is to say, that the actions of the workman in the course of time become automatic, thanks to training and practice. This may appear to be advantageous from a biological point of view, because auto-
matic movements do not call for sustained attention or an effort of will, and therefore involve the minimum of energy, nor do they add nervous to muscular fatigue.

While however from the point of view of output, automatism may appear an advantage, morally it lowers the workman in his own eyes, so that he comes to regard himself as a mere machine. Further, the continuous and stereotyped repetition of fixed movements brings about hypertrophy of certain groups of muscles, and, in the case of the young whose development is not complete, deformities of the bones may even be produced.

(c) Mistaken Value of the Methods and of the Physiological Results

In the problem he set himself to work out, Taylor was preoccupied with the question of time. He looked upon man as a piece and tried to convert him into one, while the better course would be to adapt the machine to the man.

The human motor is governed by laws other than those of a machine, and the difference is in the phenomenon of fatigue. Taylor judged the degree of fatigue of the workman by the extent, greater or less, in output. But such an appreciation cannot have the value of a strictly objective experiment.

However clever the observer may be, he cannot gain such precise information as is furnished by a scientific examination. Evidently a clearly defined task can be carried through, up to a certain point, without overstrain, provided that the work to be performed is wisely planned and takes into account the physiological powers of the workman. But in order to judge whether a task is, or is not, within the physiological capacity, an examination of when and how the functions of the body become modified is of importance. It is a matter of common knowledge, however, that in the present stage of scientific progress an objective test of fatigue is by no means easy. To acquire this information several kinds of tests have been proposed. Taylorism must be completed by technical measures calculated to aid the workman in the accomplishment of his task; and just as the machine requires the care and attention of a technical expert, so the worker requires care and attention on the part of a physiologist who must supervise and study each case.

The mechanical side of Taylorsim, however, has undergone a change with time. While at the beginning its advocates were very anxious for the transformation and utilisation of industrial technique, so now the modern developments of "scientific management" are more and more preoccupied with the human factor. In the course of the last few years the study of industrial physiology and psychology have increased. Methods capable of preventing strikes and ensuring a constant co-operation between the different organisations of productive have been methodically worked out. These researches are to-day part of the scientific organisation of labour in America, and have the same object as the strict application of the principles of Taylor in the factory and workshop. The proof of their success is seen in the changed attitude of the workpeople, who recognise that the efforts made, with the object of increasing production, have become more and more humane, and that more attention is paid to the human side and to the health of the workers.

In Europe, in spite of the deceptive experiment made before the war, the necessity for considerable effort at reconstruction has started afresh the problem of the scientific organisation of labour. Employers and employed have declared they are at one, in principle, in recognising the value of truly scientific methods as alone capable of meeting the necessities of production, running parallel with the social needs of the working class consumer. The International Labour Office interpreted this general sentiment when it proposed, in 1920, to institute a service of industrial technique, the object of which would be to study internationally problems bearing on scientific management. This view took concrete form when, in conjunction with Messrs. Filene and Dennison, the Labour Office leased the International Management Institute.

At the present time a large number of scientific and technical experts expend their activities in the study of the problems of scientific management, and it can truly be said their aim and object are to safeguard the human side.

Foremost amongst the work effected by these experts should be mentioned the enquiries of Atzler, Biasi, Buyse, Ferrannini, Frois, Giese, Joteyko, Lahy, Langlois, Lipmann, Moede, Myers, Patrizi, Pioskowski, and the great Pleadian constellation of British investigators who work under the Industrial Fatigue Research Board of Great Britain, of which the Secretary is D. R. Wilson.

Next comes another class of investigator, the number of which con-
Rhythm of Machinery

In industry the workman is bound as to his own activity by the inexorable rhythm of machinery which it is often beyond his capacity to keep pace with. For instance, in the textile industry, the number of throws of the shuttle that a weaver can manage to make is from 75 to 80 a minute. At the present time a weaving machine can make 33,000 throws in ten hours. The most that the strongest and most intelligent workman can manage is from 18,000 to 20,000, and a woman 13,000 only. This example illustrates what a continuous effort a man must make to keep pace with a rhythm which is not physiological, is unduly rapid, and leaves out of account, moreover, the sterile functioning of machinery (Viale). This is still more evident in Lancashire, where a weaving machine can make more than 80,000 throws in ten hours with an ordinary output of about 80 per cent., so that the number of throws a workman has to attend to reaches 64,000.

In the organisation of the future, harmony must be sought between the machine and the worker; on the one hand, a psycho-physical, intelligent selection of workmen, and endeavour to transfer the phenomenon of fatigue to the functioning power of the machine. The speed of the machine undergoes no variation whatever be the hour of the day, while, in the case of the worker, fatigue goes on increasing, and a rhythm of work which may be suitable at the commencement becomes excessive at the end of the day. Theoretically it should be possible to slow down the machine in proportion to the lapse of time, following a curve which would correspond exactly with the degree of fatigue. This ought to be an extremely useful innovation in industry in the future, and should make allowance both for economy of the motive and of the human capacity. To load anyone up with work who is already fatigued involves expenditure of an amount of energy very much above the normal.

Rhythm of Work

Where on technical grounds the movement of the machinery cannot be altered, then a rhythm of work should be adopted which would not be likely to induce fatigue. The physiology of work has taught how important it is to have a break between two periods of work. With pauses suitably arranged the muscles seem to be inexhaustible. The labor of the fingers of the right hand, for example, loaded with 6 kg., if they contract only every ten seconds, show no signs of fatigue. The ideal rhythm may not be the same for all the muscle groups or for all operations: it must be determined for each particular case.

Monotony of Work

The monotony which characterises machine work has already been referred to. This exercises a double influence on the body and spirit of the

Physiological Principles of Scientific Management

Fatigue (excluding certain transformations of energy which are comprised in the cycle of the general principles of thermo-dynamics) is the prominent fact which distinguishes man from a machine in function. The physiology of fatigue has as its task to endeavour to overcome fatigue, which is the most striking feature in the technology of the human motor. Fatigue diminishes muscular power, weakens the power of attention, causes the movements to go more slowly, and increases the number of accidents, while at the same time raising the coefficient of loss in the working of the machinery.

Fatigue, accumulating in the system, is the cause of overstrain and interferes with nutrition. It modifies the growth of young persons, and, in women, predisposes to miscarriages and difficult labour.

Since there is no practical indicator of early fatigue, the necessity arises of organising manual labour so as to prevent fatigue and overstrain caused by the accumulation of fatigue.

Monotony of Work

The monotony which characterises machine work has already been referred to. This exercises a double influence on the body and spirit of the
workman. Cevidalli, for instance in regard to physical influences, has laid stress on the skeletal deformities and visceral changes, especially in the young. While recognising that uniformity is a necessary condition for a given task to be accomplished quickly with the minimum expenditure of energy, it should be remembered that if this activity is of a local nature then the organism works at a disadvantage and some compensatory action should follow. This compensation can best be obtained by means of physical exercises, sport of one kind or another, giving play to the muscles and joints that have been kept in a bad position or in a state of inertia.

The unfavourable effect of monotony on the psychic state of the worker is no less important. Constant repetition of the same movements has been found, in the end, to make the workman lose interest in his job, and he does his task entirely without, or with the minimum, attention and will (Buyse). The fact that workmen take on the job they are set to without much objection is not to be taken to mean that it suits their mentality; it is only the expression of necessity, of its money value, or, perhaps, of indolence (Donaggio). When it would appear, adapt themselves more readily to monotonous work than men. Workpeople welcome change and work with pleasure at a new job with the object of becoming good at it so as to secure greater output. But as soon as this output is reached without effort they lose interest again and the desire for a change makes itself felt (Donaggio).

To obviate this state of things the workman should be given the chance of employing his mind during his work. This, however, is only possible with his intellectual faculties. These he can acquire during his leisure time, and thus indirectly monotonous work raises the question of how the man can best employ his leisure. Donaggio presented a resolution with this in mind at the Italian National Congress of Medicine held in Venice in 1924, to the effect that, in order to combat the monotony of work, the question of the organisation of leisure should be looked upon as an important matter quite apart from the organisation of hygiene in the factory.

**Load Placed on the Muscles**

When it is not considered economical to slow down the rhythm of shifts of workmen, or to introduce pauses in their work, it would be well to lessen the load (weight of tools, piece work, etc.), in order to arrive at what physiologists call the final maximum weight, thanks to which the value of the contractions, muscular activity, and output, do not fall off, even although work is carried on for long hours.

Even Taylor recognised overstrain, in selecting for each workman the task proportional to his strength and capacity.

**Energy Requirement in Work**

By analysing the movements in carrying out a set task it is important to get the workman to dispense with all movements which do not assist in the accomplishment of his job and only constitute a useless expenditure of force.

The abolition of these so-called "parasitic" movements makes the act more rapid and enables a better output to be achieved; it is the object of Taylorism. But instead of Taylor's formula of "Find out the most rapid technique", from the physiological standpoint we should substitute the formula "Find out the technique which calls for the minimum amount of force". The two formulae cannot always be combined. Study of human energy producing power has already led physiologists to lay down certain rules of general application which it would be well to adapt to the technique of industrial operations.

Movement rhythm, its extent, the load on the muscles may vary while carrying out the same piece of work. Our body has been shown experimentally to consume less energy when it uses more movements in lifting a light weight, that is with a weight always the same the work can be done with frequent and short movements, or few and large, just as marching can be done with short but rapid steps, or with long and slow ones, or a staircase can be climbed step by step or two by two. In this case similarly the human machine consumes less force when the work is broken up and the movements are more frequent but shorter.

Moreover, in maintaining a constant rhythm a workman will effect his task more easily by wide movements with light loads and short movements with heavy weights. In every case strain is the thing to try and avoid. To sum up, the greater the number of muscles taking part in a piece of work, so as to distribute it, the more is the consumption of energy reduced. As a matter of fact, two-handed work is more economical than one-handed. Work done with the left hand (even in left-
handed individuals) involves greater expense to the organism than when it is done with the right. It is rational, therefore, to teach children to use the right hand in preference to the left.

The factor of environment seems to have a great influence on the amount of output. Work, for instance, at a high altitude is less economical than down below; work at a low temperature makes less demands than at a high one. On empirical grounds an increased ration is given to Alpine soldiers.

Other factors may influence work, such as light, ventilation, tobacco, alcohol, the emotions, etc. Up to the present these problems have been treated not from the point of view of energy-producing power, but from that of industrial hygiene, in taking account of the mechanical output which a workman under certain conditions can furnish. Really in the problem of human work no solution can be given which takes into account only the question of the energy-producing power.

Individual Factors

Man, however, is not merely a machine. He has also a soul. All human work has a psychological, individual aspect, of which it is important in the highest degree to take account in psychological organisation. Age, sex, and race have their importance, but it is not yet known if a given piece of work costs a woman or a child most or to what race the workers belong who can produce the highest output. Mention only is made of the result of certain ergographic tests tending to show that women seem to be more apt than men in preserving in work which does not call for big efforts. Thus, women are said to be better at repetitive work, men at work demanding more or less expenditure of energy. This is not the place to discuss these details, which have not as yet been sufficiently studied from the scientific point of view. (See article "Women's Work ".)

Hours

Legislation in every country has recognised the need for putting a limit on the number of hours worked in industry. Adoption of the eight-hour day is a wise measure. In the distribution of hours, however, sight should not be lost of the advantage of dividing the hours of work rather than demanding continuous labour. Indeed, as has been demonstrated by ergographic and chemical means, the last hours of continuous work, as well as overtime work, cost a great deal more than the first.

By reduction in the duration of work output is not diminished. This has been recognised, even on the employers' side. An employer has for instance stated that the hours of work in his factory at the commencement of the war were increased to fifty-three per week, and in the case of women was extremely surprised to find they lost on an average fourteen hours each per week. These fourteen hours of lost time brought the weekly hours of work down to thirty-nine for each worker. "That cannot go on", he said, "let them come an hour later each morning and let them go an hour earlier in the evening ". The week's work was then reduced by twelve hours. The employer then found that with a week of forty-one hours the time lost was on the average one hour per worker per week. They worked forty hours instead of thirty-nine as before; but he found further that during these forty hours (after deducting the lost time) there was a weekly increase in output amounting to 44 per cent. (Lord Leverhulme).

Stanley Kent laid stress on the fact that "the time lost by factory operatives makes on an average 10 per cent. of the day's work. The total sum of lost time varies with the length of the day's work and would seem to be dependent on fatigue ".

Workpeople react, moreover, against a system leading necessarily to exhaustion and a tradition of slowing down. As arranged, probably automatically, and as a kind of physiological "self protection " (Kent). In taking account of this state of things, the British Committee which was appointed during the war to study the question of industrial fatigue stated: "Without some conscious or unconscious slackening of effort indeed during working hours of improper length in the past, the output might have been even more unfavourable than we know it to have been for the hours of work consumed ".

Vernon, who studied the effect of the reduction in the number of hours worked daily on output in the case of different kinds of industrial operations, made interesting observations in studying the milling of the caps of shells by young persons where acceleration was technologically impossible. "Every reduction in the duration of work time required a strict time limit; nevertheless after reducing the weekly number of hours from 72$\frac{1}{4}$ to 54$\frac{3}{4}$ — a reduction of eighteen hours or 25 per cent. — the observer could show that the decrease in the total weekly output
was very small — it was only 3 per cent — and that consequently there was an hourly increase in output of 29 per cent. How could this be possible seeing that the rhythm of the operation proper could not be accelerated?

Vernon thinks the workers could only obtain this increase by feeding the machines more continuously during the whole middle of the day. They were running (quoted by Milhaud). This meant that before the daily reduction in hours an automatic slowing down existed to preserve the workers from undue fatigue.

Finally, as further evidence in favour of a reduction in the duration of work, there may be quoted here the conclusions drawn up by an official committee appointed by the Public Health Service of the United States where it is stated that the principal characteristic of the system of eight hours is the constant maintenance of output at the same level, and that the principal characteristic of the ten-hour day is the progressive diminution of output.

PHYSIOLOGY OF REST

The physiology of rest constitutes a principal part of industrial physiology. This fact has been recognised by physiologists and medical men and mention may usefully be made here of the principles which have been laid down on the subject by the Association of German Industrial Surgeons (Arbeitsgemeinschaft der deutschen Gewerbeärzte):

(1) All prolonged work — physical or physiological — ought to be broken by rest periods. If that is not done fatigue increases to excess, while the capacity for output diminishes considerably. The necessity for rest periods has been established by scientific experiment and practical experience.

(2) The rest periods ought to come during the period of work itself. It is physiologically wrong to do away with periods of rest during worktime on the ground that sufficient rest can be obtained after work is over. The right time for and length of the rest period depends on the nature and duration of the work. Further, other external factors often have to be borne in mind (train service, etc.).

(3) Normally output diminishes towards midday. The physiological curve of the daily activity shows a fall, thus indicating that that is the period for the longest break for rest and dinner. With this point of view it is necessary to fix on an effective break of at least an hour, provided that the workman has not to go a long distance from the works to the place where he has his meals. When the distance between the factory and the home is considerable the break should be proportionately increased. The same provision should be made in the case of persons employed on poisonous materials in order to allow them sufficient time for washing and changing their clothes.

A canteen should be provided close to the factory for workmen who live too far away for them to go home for meals. Brightness in the equipment of the canteen contributes to make it restful.

(4) Continuous work (as in England) without breaks has been the custom in large cities. But despite some apparent advantages the procedure has considerable disadvantages in the point of view of the physiology of work, which shows that this arrangement of the daily round is not a sound one. A preliminary essential condition for a long spell of work is a good nourishing breakfast before commencing work and a short break at midday for lunch, which should include at least one hot dish (tea or soup).

(5) In addition to the principal rest pause secondary pauses should be introduced. Some breathing or easying of this kind are required for certain kinds of work. Where this is not the case a short pause of from ten to fifteen minutes should be made in the forenoon and third afternoon. The best time for, and duration of, these short pauses depends on the special conditions of work. Very early start in the morning and long travelling before arrival at the factory, for instance, make a fairly long rest pause necessary early on in the morning. In some instances hours described as "short hours" (Kurzstunden) (fifty minutes' work and ten minutes' rest) are very useful.

(6) The custom recently adopted of reducing as much as possible, or doing away altogether with rest periods is contrary to all principles of industrial physiology and is exhausting for those who have to carry out the work. This is true for the healthy adult worker and still more so for the weak and the ailing, and for women and children.

(7) Where the principles of industrial physiology receive adequate consideration, working energy is maintained, total output is increased and possible employment is prolonged.

Neglect of these same principles leads to insufficient repair from the fatigue engendered by work, to early exhaustion, and to ill-considered utilisation of the most precious asset the workman possesses: his capacity for work.

The industrial surgeons of Germany consider it their duty to call attention to the importance of these principles of industrial physiology. But it is, moreover, the duty of the workpeople themselves and of their leaders to resist any unreasonable shortening or stoppage of their rest periods.

It is well known that the muscles ought to recover their strength and power in order to reach their maximum output. Thus, to restore the body it is necessary to rid it of the products of muscular
exchange (kino toxines, lactates, salts of potassium, etc. and supply the muscles with fresh energising materials (carbohydrates, fats, proteids).

The body loses its toxins when resting, especially if the place is well ventilated, because the oxygen burns up and destroys the waste products of work and helps in rebuilding the energising material in the muscles.

The disintoxication of the fatigued body can be secured by drinking fresh water, or better still bouillon or salt solution, rather than alcoholic beverages. Elimination of toxins should be facilitated by the circulatory and renal functions, and disturbance of the heat-regulating mechanism of the body, so frequent among workmen, should be avoided.

The second phase, which is that of recovery of the sources of muscular energy, is obtained not only by an adequate supply of fresh air, but also by sound feeding, in which should be combined carbohydrates (glucose being the most consumed substance while at work), fats, proteid substances and vitamines. Whether a vegetarian or mixed diet is best is not known.

The principles which have been briefly discussed here belong to the domain of industrial hygiene. They can bring man's output to its highest level without interfering with the harmony of the functions of the body.

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Prof. G. Viato
(Genoa).

Seamen (Pathology and Hygiene of)


Two classes of work are carried on on board ship, one of which has to do with the navigation and safety of the ship, effected by sailors and engineers, and the other with work similar to that carried on ashore, done by bakers, domestic servants, musicians, radio-telegraphists and the like.

The latter class in no way differs very appreciably from similar industries carried on ashore, but the former class, on the other hand, possesses special characteristics.

The crew entrusted with the nautical operations include the deck-hands and the engineers.

The deck-hands include the seamen properly so called, who carry on the work of navigation, cleaning, loading and unloading of the holds; the engineering staff are in charge of all the machinery and allied services, and include the engineers and firemen.

On board ship the division of work into specialised categories is carried to the extreme limit.

The work done by each class of the crew is different in nature and duration, in port as well as on the voyage. However, in ships with small crews both deck-hands and engineering staff may do work inappropriate to their grade.

Conditions of Work

The conditions of work of the crew are contingent, i.e. common to all the personnel, and intrinsic, varying according to the two groups.

The first comprise conditions of (a) place, (b) time, (c) duration, and (d) training.

(a) In port, a seaman's work is moderate and perfectly regularised by a time-table, just as in factories; night-work is limited to care of the ship, both internally and externally. When at sea, however, work is continuous, and is especially fatiguing in rough weather.

(b) A seaman must work whatever the weather, and when it is bad his work becomes arduous.

(c) The duration of work is fixed by the engagement contracts; in some countries it is eight hours a day divided into two parts of four hours each. The time-table cannot, however, be strictly observed, as in the case of
factory workers, for the state of the sea, the handling of the ship on entering and leaving port, and other circumstances make extra and heavy work inevitable. A sailor’s work has two disadvantages: discontinuity of sleep and the absence of any weekly rest during the voyage.

(d) Training is the best preventive against physical fatigue, and this explains why men who are not accustomed to life afloat, such as cadets and cabin-boys, waste a good deal of nervous energy and muscular strength, and experience far more fatigue than do seasoned sailors.

In examining intrinsic conditions it is found that the work allotted to the deck-hands is as follows:

(a) Navigation: concerned with steering, anchors, windlasses, masts and boats. All of these operations are characterised by being performed in the open air.

(b) Cleaning the various parts of the ship, including washing down the decks. — Tons of sea water are pumped over the upper decks every morning; the sailors generally paddle about with bare feet, and only occasionally wear rubber boots.

(c) The loading or unloading of the holds in ports. — This is done by some of the deck-hands, helped if necessary by the dockers in the ports.

(d) Painting. — Includes taking off an old coat and applying fresh varnish.

The engineering staff is engaged on the following processes:

(a) Control and supervision of the machinery. — The mechanical power on most steamships is obtained by burning coal or oil; electric power, obtained by transforming the thermic energy of Diesel motors, is now also used. The work of the engineering staff is not so fatiguing from a physical point of view; it is more mental than manual and calls particularly for alertness.

(b) Supervision of fires and boilers. — The furnaces for burning coal and oil are arranged in compartments, the capacity of which varies from 100 to 400 cubic metres. The ventilation required to maintain combustion is so great that it calls for a renewal of the air sixty times an hour. This necessity does not exist on ships with internal-combustion engines; in consequence, the ventilation in those cases is less active. The labour on coal-burning ships demands a great expenditure of physical energy, with a reduced consumption of mental force. On oil-burning ships, the oil is distributed to the furnaces by sprayers, thus eliminating the manual labour, and the necessary work is reduced to superintending the apparatus.

(c) Loading coal into the bunkers and moving it from the bunkers into the stoke-holds. — The firemen employed on these processes work in cramped positions, in places which are narrow, very hot, poorly ventilated and in an atmosphere charged with very fine dust. On large ships they have, in addition, to traverse some distance along very narrow openings carrying heavy loads.

(d) Loading oil on oil-burning ships. — The supply is carried out mechanically by motor-pumps, which draw the oil from reservoirs and pump it into the tanks on board.

(e) Examination and painting of double bottoms. — There are spaces arranged between the two bottoms of a ship, which usually remain empty or are used as cisterns for drinking water. Firemen have to visit these spaces from time to time for the purpose of drying and renewing the covering of the walls.

**Sources of Dangers**

Work in the open air is carried on whatever the weather, day and night, exposing the deck-hands to meteorological conditions and to the extreme fatigue associated with night-work.

The daily washing down of the decks, carried out with their feet in water, affords sailors, when they have become accustomed to it, an excellent means of hardening their bodies against rheumatism.

On the other hand, work in the bunkers exposes the men to the action of physical agents, like dust, to chemical changes in the air, and to such biological agents as pathogenic micro-organisms.

The dust is of a very varied nature. It reaches its maximum when such material as grain or coal is put into the holds pell-mell; but it is relatively slight when the material is delivered in sacks. The nature and solubility of the substances with which it comes in contact affect the action of the dust: it may act mechanically and locally on accessible mucous membranes and the skin, or chemically causing general poisoning.
The chemical composition of the air in the holds may, owing to reaction with the materials they contain, be affected by qualitative changes, i.e. by diminution in oxygen, due to absorption by such materials as coal, maize or resin, or by qualitative changes, due to gases and fumes given off by such materials as petrol or asphalt, by gases formed by combination with the elements of the air, giving rise to methane, carbon monoxide, etc., or by gases liberated by the processes of decomposition, in the case of undressed skins, guano or ferro-silicium.

The loading and unloading of materials affected by pathogenic agents or of bunkers where animals, such as rats and insects, have infested, are carriers which act as a source or as carriers of such infection render the crew liable to contract diseases transmissible by contagion and by inoculation. From this point of view, skins, bristles and rags may transmit anthrax or pyogenic infections, and horses may transmit glanders to the men who have to tend and clean them.

The work of chipping and scraping the sides of the ship painted with varnishes and colours may originate a considerable quantity of dust which is injurious when the covering materials contain lead compounds. The use of rapidly drying varnishes in poorly ventilated places may give rise to very poisonous emanations.

Manoeuvring machinery for raising the anchors or for controlling the steering may occasion injuries which become manifest during the voyage. The work of loading and unloading the holds in ports at times causes violent injuries.

The sources of danger for the engineering personnel lie in the physical state and chemical composition of the air.

When the engines are running, the air temperature in the principal engine-rooms is about 40° C. Humidity is also increased. In the secondary engine-rooms the air temperature often exceeds 45° and the moisture reaches saturation point. On the other hand, in the stoke-holds the temperature and humidity of the air are not so high as in the proximity of the engines. Hence a prolonged stay in these places — as well as the heat variations, great and rapid, when passing from overheated places into others less heated — throws a heavy strain on the mechanism of the body. Nocht found in f iremen working in stoke-holds temperatures (under the armpits) varying between 37.5° and 38° C.; but Nespor, under identical conditions, observed it to be in the neighbourhood of 38° C. and the pulse about 140. In the principal and secondary engine-rooms, Belli observed that the engineers stood temperature rising to 60°-70° C. without trouble, provided that the humidity of the air was not raised (see below, Pathology). In the engine-rooms on steamships the maximum quantity of carbon dioxide found by Belli was 0.70 per thousand; in the ordinary way it did not exceed 0.50.

Schwartz in 1929 reported the results of his health research made on board during a voyage round Africa. In the engine-room and the stoke-hold the hygienic conditions during navigation in the tropics were not good, even in first-class ships. While the work is not too hard, except in the case of urgent repairs, it requires, on the other hand, a heavy burden of responsibility from the men. In the stoke-hold the conditions are better, but the physical labour is much harder.

The ventilation in the boiler-rooms is so good that the air is perfectly pure beyond the immediate vicinity of the furnaces. On motor vessels, where the exhaust from Diesel motors is discharged outside, theoretically the air should not be liable to any change from the products of combustion.

Another cause leading to vitiation of the air of workplaces is dust on vessels using solid fuel. The taking on board of coal into the bunkers and moving it to the furnaces give rise to a great amount of dust which, on an average, reaches 2 grm. per cubic metre of air.

On ships burning oil small quantities of volatilised oil escape from the joints, the pipes and valves, and, being heavier than air, settle in the lowest parts of the places.

In the empty spaces of the double bottom, which are constantly kept closed, the oxygen is absorbed by the varnish with which the sides are covered as a protection against rust.

The supervision and handling of the engines, and associated services, may cause serious occupational injuries, which are common among firemen.

**Statistics**

According to some American statistics, provided by M. R. King, relating to the sailors of the Eastern Squadron treated in hospital in the ports of Manila, Philippine Islands, from October 1920 to February 1923, the classification of the various diseases was as follows:
In a report of the British Admiralty published in 1927, which gives the health statistics of the Navy for the year 1924, the morbidity and mortality rates for the year 1924, compared with those for the three preceding years 1921-1923, are as follows:

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<tr>
<td>African Stations</td>
<td>387.56</td>
<td>652.33</td>
<td>34.37</td>
<td>47.26</td>
<td>4.76</td>
<td>4.29</td>
</tr>
<tr>
<td>Irregular lists</td>
<td>304.45</td>
<td>467.06</td>
<td>14.78</td>
<td>28.86</td>
<td>2.86</td>
<td>4.01</td>
</tr>
<tr>
<td>Total of strength</td>
<td>450.24</td>
<td>542.39</td>
<td>14.51</td>
<td>20.13</td>
<td>3.9</td>
<td>3.11</td>
</tr>
</tbody>
</table>

Mortality in the British mercantile marine is shown in the table below, which gives the figures for the years 1901, 1911-1912, 1921, 1926 and 1928 according to the various causes of death:

<table>
<thead>
<tr>
<th>Disease</th>
<th>1901</th>
<th>1911-1912</th>
<th>1916</th>
<th>1926</th>
<th>1928</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of first crews</td>
<td>146,860</td>
<td>165,159</td>
<td>173,110</td>
<td>159,950</td>
<td>164,300</td>
</tr>
<tr>
<td>Percentages taken</td>
<td>137,170</td>
<td>148,640</td>
<td>121,177</td>
<td>143,995</td>
<td></td>
</tr>
<tr>
<td>Number of persons taken</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deaths</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enteritis</td>
<td>35</td>
<td>0.27</td>
<td>58</td>
<td>0.39</td>
<td>27</td>
</tr>
<tr>
<td>Smallpox</td>
<td>17</td>
<td>0.13</td>
<td>8</td>
<td>0.05</td>
<td>3</td>
</tr>
<tr>
<td>Malaria</td>
<td>98</td>
<td>0.92</td>
<td>31</td>
<td>0.21</td>
<td>40</td>
</tr>
<tr>
<td>Tuberculosis (all forms)</td>
<td>45</td>
<td>0.34</td>
<td>44</td>
<td>0.29</td>
<td>56</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>50</td>
<td>0.38</td>
<td>52</td>
<td>0.35</td>
<td>56</td>
</tr>
<tr>
<td>Diseases of the circulatory system</td>
<td>136</td>
<td>0.90</td>
<td>88</td>
<td>0.59</td>
<td>55</td>
</tr>
<tr>
<td>Suicides</td>
<td>69</td>
<td>0.52</td>
<td>46</td>
<td>0.30</td>
<td>39</td>
</tr>
<tr>
<td>All diseases</td>
<td>555</td>
<td>4.07</td>
<td>549</td>
<td>3.87</td>
<td>502</td>
</tr>
<tr>
<td>Alcohol</td>
<td>120</td>
<td>0.91</td>
<td>111</td>
<td>0.74</td>
<td>42</td>
</tr>
<tr>
<td>All accidental deaths</td>
<td>978</td>
<td>7.40</td>
<td>1,003</td>
<td>6.95</td>
<td>461</td>
</tr>
<tr>
<td>All causes</td>
<td>1,603</td>
<td>12.50</td>
<td>2,133</td>
<td>14.35</td>
<td>865</td>
</tr>
</tbody>
</table>

1 Pulmonary tuberculosis
2 664 (4 per cent.) drowned in the Titanic catastrophe.

A Board of Trade publication gives particulars of the mortality of the crews of ships as defined by the Merchant Shipping Act, 1894, during the year 1927. The number of deaths among the crews of steam-ships and motor-ships (other than

<table>
<thead>
<tr>
<th>Disease</th>
<th>Number of cases</th>
<th>Days of sickness</th>
<th>Percentage of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hernia</td>
<td>11</td>
<td>304</td>
<td>3.09</td>
</tr>
<tr>
<td>Dengue</td>
<td>16</td>
<td>147</td>
<td>3.84</td>
</tr>
<tr>
<td>Nervous and mental diseases</td>
<td>17</td>
<td>448</td>
<td>3.83</td>
</tr>
<tr>
<td>Forms of rheumatism</td>
<td>18</td>
<td>373</td>
<td>3.92</td>
</tr>
<tr>
<td>Diseases of the skin</td>
<td>20</td>
<td>348</td>
<td>3.85</td>
</tr>
<tr>
<td>Alcoholic intoxications</td>
<td>25</td>
<td>277</td>
<td>4.73</td>
</tr>
<tr>
<td>Gastro-intestinal diseases</td>
<td>40</td>
<td>792</td>
<td>8.56</td>
</tr>
<tr>
<td>Wounds</td>
<td>61</td>
<td>966</td>
<td>9.10</td>
</tr>
<tr>
<td>Diseases of the thorax</td>
<td>63</td>
<td>817</td>
<td>9.18</td>
</tr>
<tr>
<td>Other diseases not classified</td>
<td>90</td>
<td>1,467</td>
<td>17.11</td>
</tr>
<tr>
<td>Venereal diseases</td>
<td>160</td>
<td>3,842</td>
<td>30.42</td>
</tr>
</tbody>
</table>

Total | 526 | 9,306 | 100.00 | 100.00 |
fishing boats) was 1,194 classified as follows:

<table>
<thead>
<tr>
<th>Cause</th>
<th>Deaths at sea</th>
<th>Deaths in rivers or ports</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipwrecks</td>
<td>74</td>
<td>33</td>
<td>107</td>
</tr>
<tr>
<td>Other accidents:</td>
<td>108</td>
<td>98</td>
<td>206</td>
</tr>
<tr>
<td>on board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ashore</td>
<td>-</td>
<td>195</td>
<td>195</td>
</tr>
<tr>
<td>Diseases</td>
<td>216</td>
<td>630</td>
<td>846</td>
</tr>
<tr>
<td>Homicides and suicides</td>
<td>50</td>
<td>22</td>
<td>72</td>
</tr>
<tr>
<td>Total (including Lascars)</td>
<td>457</td>
<td>737</td>
<td>1,194</td>
</tr>
<tr>
<td>Lascars</td>
<td>112</td>
<td>137</td>
<td>249</td>
</tr>
</tbody>
</table>

Disease is shown to have been a much more frequent cause of mortality among Lascars than among other members of crews, although it was the principal cause of death for all cases. About three-quarters of the deaths among Lascars were due to disease; of this rate, 20 per cent., were due to tuberculosis and 18 per cent., to pneumonia. Among seamen other than Lascars a little over half of the deaths were due to disease, the principal affections being tuberculosis (12 per cent.), pneumonia (10 per cent.) and cardiac affections (10 per cent.).

The principal causes of death from trauma and accidents were as follows (in percentages): suicides or supposed suicides, 13; falls into the water from quays and accidents ashore, 16; falls overboard and fatal accidents on board, 10; boats lost, 9; disappearances at sea, 9; falls down hatchways, etc., 8.

Deaths among crews of fishing boats as defined by Part IV of the Merchant Shipping Act, 1894, totalled 109. Of this number, 35 were due to shipwrecks, 50 to other accidents, including homicides and suicides, and 24 were due to diseases.

According to the calculations of the Registrar-General of England and Wales, the general mortality of seamen was found to be 76.8 per cent. in excess of that of all occupied and retired males. As regards tuberculosis, this excess is represented by 35.5 per cent.; for violent causes of death the general average is five times higher in the case of seamen. As regards the mortality for various other causes, high percentages have been recorded for infectious diseases: pneumonia, influenza and other respiratory affections, rheumatism, abscesses, wounds and other septic conditions.

The final invalidity of officers and seamen is ascribed to infectious diseases (tuberculosis, 166 times; primary syphilis, 6; secondary syphilis, 26; gonococcal infections and their sequelae, 253); to nervous and mental troubles (diseases of the spinal cord, 7; paralysis, 4; epilepsy, 35; neurasthenia, 58; other affections of the nervous system, 71; insanity, 31); to diseases of the special sense organs (eyes, 174; ears, 116); to diseases of the circulatory system (cardiac affections, 67; veins, 11); to diseases of the respiratory system (bronchitis, 12; asthma, 4; pulmonary fibrosis, 41; pleurisy, 3); to diseases of the digestive system (stomach, 15; intestines, 6; hernia, 35); to diseases of nutrition and metabolism (diabetes, 1); to diseases of the genital system, the locomotor apparatus, and of the skin and the cellular tissue (skin, 12); to diseases of the urinary system, neoplasms (4 cases), alcoholism (2 cases), and wounds.

In Germany, H. Ruge found that infectious diseases occupied the first place among the diseases of seamen: typhoid fever, typhus, dysentery, and, in the tropics, yellow fever and malaria.

These returns referred chiefiy to the times of the old voyages of discovery: At the present time the diseases of seamen in the German mercantile marine can be divided into four principal groups: those caused by exposure to cold, mechanical injuries, inflammation of connective tissue and venereal diseases. Under the diseases caused by exposure to cold are tonsillitis, laryngitis, bronchial catarrh, pleurisy, catarrh of the lungs, and injuries of the musculoskeletal system and articulations. The engineers, or rather the firemen, are the most affected. But mechanical injuries are more frequent and more dangerous on sailing ships, where the mortality has reached 39 per cent., whilst it is only 5 per cent. on steamships. Accidents in the engine-rooms are quite unusual. As regards division by categories, it is found that recruits are more affected than the old hands, and that accidents are more common on Monday and at the beginning of the week than towards the end; 55 per cent. of accidents occur during work.

Boils, which also cause incapacity of long duration, are generally situated on the arms, and occur more often among firemen than among seamen, and they reach their peak in summer, with a recrudescence in the autumn, when new hands are recruited.

In Italy the mortality among those drawing pensions for invalidity from the mercantile marine for 1914-1924 remained at a much lower rate than that of the civil population.

The various statistics, although fragmentary, give the impression that, of recent years, the hygienic conditions of the merchant service have become satisfactory in Italy.

This improvement, of which it is impossible to determine the exact extent, but which remains nevertheless established fact, is due, in part at least, to measures recently adopted on behalf of the merchant service.

The causes of the most widely spread diseases among Italian merchant seamen, as everywhere else, are venereal diseases (nearly 16 per cent., according to the Sickness Fund of Julian Venetia, 1926); venereal diseases (in 1924, 13 per cent.; in 1925,
Pathology

In an attempt to examine the health of seamen by reference to sickness returns supplied by the merchant services, it must be borne in mind that they are even less complete than those of mortality. In fact, the particulars are supplied only by shipping companies, trade unions or insurance institutes, and are not complete, dealing only with one group of persons and with the objects for which they have been prepared. Naval statistics are not of any more use, as service in the mercantile marine and in the Navy is not exactly homogeneous; the first includes men of all ages, from cabin-boys to old seamen, whilst the second is made up for the most part of men aged twenty to twenty-five years; the first group concerns a personnel collected haphazard, and the second men selectively, after a medical examination on engagement and in accordance with regulations. Nevertheless, the two groups are analogous as regards nautical work properly so called; in consequence, where the particulars for the merchant service are lacking, it is reasonable, on analogy, to examine the state of health of the crews of warships.

Infectious diseases are found to be the most common. According to the health returns of the British mercantile marine, given at the Oslo Conference, venereal diseases constituted 50 per cent. of all diseases. The statistics of the Julian Venetia Sickness Fund only showed 8.3 per cent.

Pulmonary tuberculosis is a serious scourge among crews, especially among the deck-hands. In France it is responsible for 9.50 per cent. of cases of sickness; in Germany 10.1.; in Italy, according to the statistics of the above-mentioned Fund, approximately 16 per cent. Nocht and other authors regard tuberculosis as an occupational disease of seamen.

Plague and yellow fever affect particularly the bunkermen, when there are plague-infested rats in the holds, or infected stegomyia mosquitoes.

Affectsions of the respiratory system, bronchitis and lobar pneumonia, and of the locomotor system, acute articular rheumatism, are common among cadets and cabin-boys, for their bodies are not yet accustomed to resisting the effects of cold. Experienced seamen, on the other hand, get accustomed to the condition and this increases their bodily resistance against the effects of cold.

The engineering personnel is less liable to the above-mentioned affec-
tions, in spite of oscillations of temperature of 30° C. and more, to which engineers are exposed during sudden moves from their workplaces to a fresher environment.

Pulmonary anthracositis is chronic among firemen who have worked as such for a long time, and is due to the penetration of coal dust into the respiratory tree.

Affections of the digestive system seem to have a particular frequency among seamen. According to statistics of the Seamen's Sickness Fund at Trieste the percentage of these affections is higher than that of venereal diseases, for in 1924 there were 480 (16.29 per cent.) compared with 328 (10.92 per cent.) for venereal diseases; in 1925, there were 483 (13.77 per cent.) compared with 349 (9.95 per cent.) for venereal diseases. The number of days of sickness was, in 1924, 15,712 for affections of the digestive system and 14,303 for venereal diseases; in 1925, 14,904 for the first, compared with 13,794 for the second. It should be noted that the cases are not always slight, for fatal cases were most common in all this group of diseases. Among the serious forms, there were noted, in 1926, 41 cases of gastric ulcer, diagnosed with certainty, and 50 cases of typhoid fever. The great frequency of digestive diseases among seamen is due to causes which can be easily removed. A better quantitative and qualitative calculation of the food ration, a judicious choice of the articles of food, better means of keeping food, especially in the tropics, as well as a stricter control of the cook's galleys, better victualling and distribution of food, should bring about a diminution in the sickness rates (Soldi). The engineering staff is the one, among the different categories, which is most easily affected by diseases of the digestive organs. One of the causes lies in the absorption of large quantities of water. A seaman may drink as much as 8 litres a day to make up for the loss occasioned by sweating.

Cases of heat cramps are fairly common on ships which voyage in the tropics, where they are regarded as heat stokes; fifty-six cases were observed during a single month (June 1926) on an American vessel, and forty-two cases were observed simultaneously on the French vessel "Bugeaud" in the Red Sea in 1900.

There is no doubt that, with the increasing use of oil fuel, heat cramp is becoming rarer and rarer. This interesting fact lies in the observation that it is not in the hot engine rooms that the onset of cramps occurs, but in the stokeholds (which are fresher and better ventilated) where the heavy work causes profuse sweating, and it is to this latter fact that the cases which occur are to be attributed rather than to the high temperature. The researches which have been undertaken have not led to any conclusive results, some authors attributing the cramps to localised dehydration of the tissues and the accumulation of the products of metabolism (Fisher), whilst others consider them as signs of auto-intoxication resembling the symptoms of severe fatigue (Winslow).

In 1928 P. Cazamian and E. E. Smith re-investigated the subject of heat cramp. The best description of the syndrome was by Pryor (1918): during or after exertion the cramps generally commence in the calves and spread to the other parts of the lower limbs and to the abdomen; the temperature may rise in certain cases; usually tetany is always found. A marked resemblance exists between these cramps and those of cholera, and Wilcox has described a type of choleriform heat stroke in Mesopotamia. Cazamian likens the cramp to the onset of tetany and attributes it to a diminution in the blood calcium ions in the blood in consequence of the sweating, and to an increase in the guanidine on account of the high surrounding temperature. According to Noel Paton, it is the ions of calcium which protect the nerve cells against attack by this substance, and Cazamian advises the administration of calcium chloride in doses of 60 grm. and more.

Investigations in Great Britain by Moss have done much to clarify the position. He ascribes the condition to an undue loss of salt in the sweat, after which plain water acts as an irritant to the thirsty tissues, and cramp results as a kind of water poisoning. If a little salt is added to the water, cramp is avoided; the men drink less of this water and are much more quickly refreshed.

Cases of sudden death may be due to tetany of the cardiac muscle, as has been observed experimentally on dogs exposed to high temperatures. After death there is found acute interstitial congestion of the lungs and swelling of the renal epithelium. Pryor recommends sugar as a preventative. In the British Navy, stokers drink oatmeal water with lemon juice and sugar.

According to Ehrengreund, the intensity of the vibrations of the ship play undoubtedly a large part in cases of sudden death on board ship. Ex-
tions of carbon dioxide, as insufficient ventilation, slow absorption of carbon dioxide, or the state of the sea. But according to this authority it is the intensity of the vibrations of the ship produced by the engines and the state of the sea, and rolling rather than pitching, which lead to cardiac or cerebral embolism, especially in individuals suffering from slight endocarditis, of which they are not aware, following rheumatic infection, which quite frequently occurs in seamen.

As regards the existence of an occupational anaemia among engineers and firemen, the haematological researches of Belli and Brancato show that an anaemia, properly so-called, does not exist, and that pallor of the face, the special symptom of this supposed condition, depends on a simple oligochromaemia which appears, only to disappear as soon as the subject leaves the place of work.

Examination of the blood of firemen working in a temperature of 48°-51° C. on board an Italian ship enabled Brancato to observe a gradual diminution of leucocytes during work in the stokehold. At the same time there was an increase of the lymphocytes and a diminution of the polymorphous leucocytes. Return to the normal was observed thirty hours after the cessation of work. During the first hours of sleep there was an increase in the polymorphous leucocytes. Brancato found, in addition, a diminution of the bactericidal property of the blood up to as much as 30 per cent. during work and immediately after.

Affections of the skin and subcutaneous tissue are common among the engineering personnel on board coal-burning ships, in consequence of the irritation and the small injuries constantly caused by coal dust.

Conditions caused by cold, such as numbness and frost-bite, affect chiefly men working in the open air.

Occupational poisonings are rare on ships, except amongst those who have to do with the transport of naphtha oil. Cases of lead poisoning or poisoning by turpentine, alcohol or benzene are observed exceptionally among men employed on painting.

On the other hand, cases of asphyxia are not uncommon among the men who descend into the holds or double bottom when the air is bad.

Violent lesions are common and serious on account of the numerous and complicated machinery on board. The greatest number of accidents are met with among the engineering personnel, and especially those who are serving as apprentices and have not become accustomed to the work.

**Hygiene**

Every kind of work may cause definite affections or definite occupational injuries; hence preventive measures should be adopted against the respective injury.

The best way of mitigating the unfavourable conditions for deck-hands working in the open air is to fit them out to face these. When the weather is severe it is desirable to provide hot drinks for the men on duty, and an extra meal, as well clothing, sea boots, woolen gloves and sou'westers.

All the well-known preventive measures should be taken against danger from dust during the operations of loading and unloading: prevention of the formation of dust by using means adapted to the kind of material, such as sacks and packing-cases; purification of the air by means of exhaust ventilators and methods for collecting the dust; protection of the workmen in the case of toxic material by means which will prevent it from penetrating into the nose, eyes and mouth, such as goggles and respirators. Wherever possible, manual work should be replaced by automatic machinery.

The prevention of casualties from vitiated air requires the application of suitable measures during the construction of the ship and during the loading and unloading of cargoes, in order to protect the workmen.

Before unloading, it is desirable to use in the holds a special system of ventilation to effect a complete change of air.

The specialisation of cargo boats, which has already been adopted for meat, fruit and oil, should be further extended, especially for cargoes which ferment easily or become decomposed.

Liquids which may give off gases and poisonous fumes must be stored in receptacles which maintain a stable position.

It should be ascertained that at the start of work the air of the holds is not irrepressible; men should descend with safety belts, under the supervision of an experienced and responsible man, and, if necessary, they should be supplied with breathing apparatus.

The prophylaxis against infectious spread by loading consists in putting the cargo in suitable holds and in the
organisation of the operations of loading and unloading. Goods capable of conveying infectious germs, or of affording shelter and food for rats should be placed in the hold in such a manner as to prevent the dispersion and transport of live animals. These operations should be done by daylight, so as to prevent mosquitoes entering the holds; rat-traps should be placed at the openings to prevent rodents having access to the holds and the ropes should be furnished with protective discs to prevent the passage of rats.

The prevention of occupational poisonings on board ship does not differ at all from that indicated for promoting industrial hygiene in general.

Means for improving the conditions of health of the engineering personnel are in the first place within the domain of the shipbuilder, and consist in lessening radiation from sources of heat by means of screens and by the use of covering media which are bad conductors; in lowering the temperature of the air; in the construction of rooms at a temperature between 25° and 30° C. in which the men may wash and change their working clothes for their ordinary clothes, and in the provision of douche baths for the cleanliness of the skin.

Masks to prevent the inhalation of coal dust are not generally appreciated by the men, who also refuse to use coloured goggles for protecting the eyes against dust and heat-rays from furnace fires.

Accidents from machinery are prevented by means of safety apparatus of a general kind or special for each machine; but an essential factor is the attention and skill of the personnel.

In life in the Navies every act is minutely disciplined. Hygienic factors are, in consequence, dealt with in regulations and contracts which fix the engagement, the quarters, food and clothing.

In all the merchant services, the crews are engaged by a simple labour contract. The shipowners engage the crews by judging their apparent capacity for work. The institution of a medical examination before engagement, which is necessary to decide on the physical fitness of candidates, as is done for ships of war, was proposed at the International Conference at Oslo (1926) and it is very desirable that it may be realised.

The elimination of men who have lost the capacity for work takes place by natural selection, men who are not in a state to resist the fatiguing life of the sea themselves seeking less arduous work. It is considered that it would be desirable to provide a system similar to that obtaining in the Army and Navy for dealing with cases for discharge and eventual transference to the half-pay list, in order to exclude from the crew those who are no longer fit for the work.

Accommodation. — In Great Britain the Merchant Shipping Act, 1894, provided for 72 cub. ft. of air space and an area of 12 ft. for every seaman or apprentice on board; these were increased in 1906 for ships of new construction and of a tonnage above 300 tons to 120 cub. ft. of air at least, and an area of 15 sq. ft. According to instructions published in 1913, cooking galleys, whatever their position, must not be considered as spaces intended for the crew, and any space reserved for the use of seamen should not contain cargo or provisions of any kind which are not the property of the crew and used by them during the voyage. As regards the height of the spaces occupied by seamen, the same instructions lay down that there must be at least 6 ft. between the flooring and the lower part of the beams.

In the majority of ships, the quarters for the crew are situated at the fore end, but there are also cabins on the sides of the ship and in the centre, on the aft deck; on board British ships of recent construction there is accommodation for the crew in the poop. The forecastle is generally composed of upper and lower quarters; the lower are under the main deck and reached by a ladder or stairs. It is very difficult to maintain healthy conditions there. Hence the Board of Trade has drawn the attention of shipowners and shipbuilders to the necessity of seriously considering accommodating the crew in cabins on deck. In new ships, hawse holes and cables must not be placed in the cabins for the crew and, when metal cables passing from an upper deck traverse a space they should be adequately protected from one deck to another. As regards lighting, the minimum obligation for necessary light is such that, in a new and freshly painted ship, it is possible to read the print of an ordinary newspaper in any part of a cabin, even if a third of the light is reduced. These conditions are not always carried out, especially in the case of quarters where the diameter of the port holes is limited, so as not to diminish the strength of the ship, and whether it is necessary to protect the glass in the port holes on account of the anchor. As regards ventilation, no definite strict rule can be set up as to the
system to be adopted. But every place used by the crew must be provided with at least two ventilators, one serving for the admission of air and the other for the exit of vitiated air. On all ships intended to voyage in the tropics, an opening, which allows the introduction of a wind-sail of at least 18 in. diameter, ought to be fixed in the deck above every space reserved for seamen, engineers and firemen. Efforts are made to obtain natural ventilation, but the results are seldom satisfactory, and even when suitable means and apparatus are provided their use is often neglected.

Every place occupied by seamen should, in addition, as far as possible, be well isolated and protected against any emanation likely to come from the cargo or the bilge water. The installation of metal bunks is recommended; they should be so placed that it is possible to enter them conveniently from the side. For each quarter of the crew the stove must be constructed so that it does not emit fumes or gases of combustion; cooking stoves should be forbidden in sleeping quarters.

The number of water closets should be in the proportion of one for 10 men up to 100; for any number above that the water closets should be increased at the rate of 4 per cent. Sufficient washing accommodation should be provided on board. Lavatories and bathrooms are necessary, especially for engineers and firemen, but the provision of water for them often presents a difficulty which has to be considered.

The sanitary condition of ships can be estimated from a report of 1918 relating to ships inspected in the port of London: in 1,496 of the ships inspected, the quarters for the crew have to be heated, the stove must be constructed so that it does not emit fumes or gases of combustion; cooking stoves should be forbidden in sleeping quarters. The number of water closets should be increased in the proportion of one for 10 men up to 100; for any number above that, the water closets should be increased at the rate of 4 per cent. Sufficient washing accommodation should be provided on board. Lavatories and bathrooms are necessary, especially for engineers and firemen, but the provision of water for them often presents a difficulty which has to be considered.

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Among these rules is one which lays down that the food must be inspected before a voyage, and that the water tanks must be emptied completely, cleaned and filled with fresh water. In many ships a serious defect is the absence of a suitable place for storing the food in a satisfactory manner. According to the instructions published in 1913, on every ship making short voyages and on which the crew themselves provide their food, store cupboards must be provided, situated as far as possible from the sleeping quarters. On a declaration that these cupboards are for the use of the crew, they may be measured and their cubic capacity added to the space reserved for the crew and deducted from the tonnage (Buchanan).

Medical attendance. — A seaman who contracts a disease or suffers from a disease during a voyage (it is sufficient that the disease is contracted during the voyage and not necessarily in the course of the man's duties) is cared for gratuitously, and receives his full wages.

The Oslo conference discussed the question of a medical service by wireless for ships not carrying a doctor. A special committee for the welfare of sailors, which has its headquarters at Paris, is working on the problem, which has already been solved in the case of several countries.

In Norway it is proposed to make compulsory the provision of an ordinary sick bay on board every ship over 200 tons which has a crew of twelve men or more; in Australia some measures of this kind are recommended for ships of more than 1,000 tons which are ordinarily at sea more than twenty-four hours without putting into port.

The crews of merchant vessels are subjected to prophylactic measures against venereal diseases in the ports of those States which have adopted

Clothing. — According to ordinary contracts, clothes are supplied by the shipowners, usually at the rate of two suits a year, of the kind always worn by seamen.

Feeding. — The allowance of food, the time for meals, as well as the weight and quality of the various kinds of food, are fixed. The allowance satisfies the requirements of health conditions in general, and, from the point of view of alcoholic drinks in particular, may be regarded as more than sufficient (Belli).

In Great Britain, the Board of Trade has issued detailed rules for the inspection of food and water on board ships. Among these rules is one which lays down that the food must be inspected before a voyage, and that the water tanks must be emptied completely, cleaned and filled with fresh water. In many ships a serious defect is the absence of a suitable place for storing the food in a satisfactory manner. According to the instructions published in 1913, on every ship making short voyages and on which the crew themselves provide their food, store cupboards must be provided, situated as far as possible from the sleeping quarters. On a declaration that these cupboards are for the use of the crew, they may be measured and their cubic capacity added to the space reserved for the crew and deducted from the tonnage (Buchanan).
the Brussels International Agreement of 1 December 1924. In most of these States seamen are subjected by law to Jennerian vaccination, and, in case of necessity, to vaccination against typhoid, cholera and plague.

In some countries, Italy for example, during the stay of ships in ports infected by malaria, the seamen are entitled to a free issue of quinine as a prophylactic measure.

**LEGISLATION**

Numerous laws regulate the work on merchant vessels in various countries which provide, in engagement contracts, insurance against accidents and diseases (tuberculosis included), medical attention on board and ashore, and social assistance to seamen’s families.

The question of assistance to the crews of merchant vessels was brought forward for the first time in 1913 at the International Conference of Antwerp, but only tentatively. After the world war, owing to the foundation of the International Labour Office at Geneva, these questions passed definitely into the international domain.

The International Labour Conference at its Session of 1920 at Genoa adopted several Draft Conventions for the protection of seamen: employment agencies for seamen (19 ratifications up to 1 April 1932); unemployment indemnity for shipwrecked seamen (17 ratifications); and age at which children may be employed at sea (32 ratifications). In 1921, at Geneva, the Conference adopted two Draft Conventions concerning respectively the minimum age for trimmers and stockers (23 ratifications) and the compulsory medical examination of young persons employed at sea (23 ratifications). The Conference of 1926 adopted a Draft Convention concerning seamen’s articles of agreement (13 ratifications) and another concerning repatriation of seamen (12 ratifications). A Draft Recommendation which was passed in 1926 deals with inspection of the conditions of work of seamen.

In view of the prevention and treatment of venereal diseases among seamen, the 1930 Session of the Conference invited the League of Nations and the International Labour Office to take steps, first, to facilitate prevention and treatment in the principal ports and to get venereal diseases classified with those diseases for which medicines and care are provided gratuitously to sailors, and, secondly, to diffuse suitable information on this subject among seamen and to provide recreation for them ashore. In order to realise this programme the International Labour Office has requested all the Governments of maritime countries, the members of the International Labour Organisation, as well as national and international organisations of ship-owners and seamen, to supply information on measures already taken or planned in the various countries.

The first result of this action was the publication in 1926 by the International Labour Office of a study entitled *Protection of the Health of Seamen against Venereal Disease*. Next, at its 1929 Session, the International Labour Conference reserved the question of the welfare of seamen, opening for discussion, among other matters, the question of the improvement of the conditions in ports and the protection of seamen in case of illness, including the treatment of injuries on board. The discussion of these questions was provisional, owing to the system of double reading adopted by the Conference. However, the results obtained were positive in the sense that the Conference decided that the two questions should be entered on the agenda of one of the next Sessions.

The questions relating to the hygiene and health of the seamen have, in addition, occupied the attention of the General Council of the League of the Red Cross Societies, which during its third session in 1926 recommended a series of measures on these lines:

(a) educational propaganda on board ships by posters, pamphlets and other means;

(b) improvement of existing, or publication of new, popular health handbooks for the use of seamen;

(c) the setting up of Red Cross stations with dispensaries in order to provide the necessary treatment for seamen; and

(d) the elaboration of plans for supplying medicine chests fitted with up-to-date drugs and material.

In 1926 the Norwegian Red Cross and the League of Red Cross Societies called a conference at Oslo which examined various aspects of hygiene in the merchant services and appointed a permanent committee for the welfare of seamen. In October 1929 the second conference on hygiene and welfare in the merchant services took place at Geneva, during which welfare in the ports in general and on board were considered, and also tuberculosis and the campaign against venereal diseases.

The International Union to Combat Venereal Disease also devoted part of its activity to the study of the prophylaxis of venereal diseases in ports, and the general secretary of the Union expounded, in an international report presented at the second conference on the hygiene and welfare of merchant seamen, the general principles of the campaign against venereal disease, and their application to maritime conditions. The creation and maintenance, in the principal ports, of venereal treatment centres open to all merchant seamen or to boatmen, without distinction of nationality, with a view to giving to these workers the necessary

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facilities for the treatment of venereal diseases, was the object of an international agreement signed at Brussels on 1 December 1926.

The fumigation of ships by means of hydrogen cyanide, hydrocyanic acid, or sulphur dioxide and trioxide was the object of an enquiry by the International Office of Public Hygiene at Paris, as well as of a series of memoranda on the part of various competent Ministries of different countries (for example, Great Britain). In most of the regulations dealing with the merchant services are found standards of visual acuity, hearing and colour vision for candidates for pilot's work (see study published by the International Labour Office in 1929 entitled Colour Vision Tests 1).

The laws and regulations concerning the engagement, discharge, repatriation and discipline of seamen have been collected and published by the Office 2.

In many countries persons employed in maritime navigation or in fishing are covered by the general legislation dealing with accidents, and in others they come under special regulations. The principle of compensation for occupational risk has been thus extended to maritime navigation, notably in Argentina, Belgium, France, Germany, Italy, Norway, Rumania and Spain. As regards occupational diseases, Germany provides compensation for exotic diseases, typhus and scurvy, when they affect seamen; Latvia, epidemic and tropical diseases, scurvy and beri-beri; and Yugoslavia, beri-beri.

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Selenium


Selenium (symbol Se) is a metallicloid rare in nature, where it is found in a free state or accompanied by selenites of sulphur, cadmium or vanadium, in crocidolite as well as in certain pyrites, molybdenite and volcanic lava. Finally, it is found in anode muds in electrolytic refineries, copper refineries or in those of lead chambers in sulphuric acid factories when selenium-bearing ores are utilised.

Berzelius encountered for the first time (1817) selenium in the mud from lead chambers. This element becomes volatilised with sulphur dioxide, and on arrival in the chambers it is deposited in part together with the other products. It may also pass into the sulphuric acid of the Glover tower. Berzelius extracted it by washing the muds and treating them with a concentrated solution of potassium cyanide. After filtration, he effected precipitation of the selenium with hydrochloric acid, which he oxidised with nitric acid. By means of evaporation he obtained oxide of solid selenium, which he purified by sublimating it. The oxide was reduced to metallic selenium by an aqueous solution of sulphur dioxide.

In chimneys of foundries for smelting selenium-bearing ores it is possible to find dust containing up to 9 per cent. of selenium. In an American factory the ore is ground and washed in a lye solution; dissolved selenic acid is precipitated as a sulphate by means of sulphur dioxide. The sulphate is then dried, ground, pulverised and sometimes melted, though melting is not necessary.

According to certain authorities, there exist only three forms of selenium at an ordinary temperature: vitreous red selenium, obtained by precipitation; the crystalline red variety which melts at 144° C. and solidifies by becoming transformed into the third type; the metallic selenium which melts at 219° C.

Selenium melts at 217° C. (the red crystals form at 170-180° C.) and boils at 665° C. In the air it burns with a bluish-red flame, giving off SeO2, and having an odour of putrefying radishes.

By utilisation of the property which it possesses, constituting it a better conductor of electricity the more strongly it is lit up, the crystalline selenium is used in the construction of telephonic apparatus with luminous rays (seleno-radiophones, photophones), or telephotographic apparatus, and also for alarm apparatus (electric eye) and in photometry, etc.

Vitreous selenium and soda selenite are also employed in the glass and pottery industries for giving a rose and red coloration, and selenium for removing the greenish colour from white glass.
Whilst metallic selenium does not appear to be toxic, the majority of its compounds are said to exercise a harmful action to which the attention of those affected requires to be drawn. These substances can be readily detected in the system, since they give to the breath and perspiration an odour of garlic, in consequence of their transformation in the body into dimethyl selenium.

The methyl and allylic compounds which enter into the composition of products for removal of stains, to reinforce the action of benzine, possess powerful toxic properties characterised by a nervous symptomatology of chronic evolution (Zangger).

Wohl and Berzélius have referred to the toxic action of seleniuretted hydrogen, having suffered from the effects thereof during extraction of the element. Berzélius relates having been the victim of accidents of this kind as the result of the effect of a single gaseous bubble no larger than a pea. According to Eulenberg, animals are on the other hand killed rapidly by this minimum quantity.

Rabuteau (1867) has engaged in a study of the physiological action of *selenates* of soda and potassium which are said to cause vomiting and diarrhoea and to impart a garlic odour, which he attributes to seleniuretted hydrogen.

According to Chabrie and Lapicque (1889) and Modica, selenium dioxide (or selenious dioxide, *SeO₂*) and selenic acid are highly toxic and their action is said to be analogous to that of arsenic (Lewin). According to Robert this action is said to recall on the contrary that of sulphur.

Seleniuretted hydrogen (hydroselenic acid, *H₂Se*), a gas smelling of putrefying radishes, exerts an action on the skin and respiratory passages: irritation of the mucous membranes, pain, loss of the sense of smell, etc.

The first experimental research in regard to the toxicity of these products was that of Japha (Halle thesis, 1842) who tested the effects of the product on himself and discovered that it gave rise to phenomena similar to those caused by arsenic (emaciation, diarrhoea, etc.).

Czapek and Weil (1893) have, on the other hand, effected experiments with sodium selenide, the toxic action of which is more rapid and more intense than that of the selenate. This compound acts like sodium arsenide and provokes excitement, dyspnoea, and finally loss of reflexes, convulsions and death.

Like the foregoing authorities, Mead and Gies (1902) have revealed the fact that symptoms caused by selenium are similar to those due to tellurium (see that article). It must however be recalled that the former does not have the effect of suspending perspiration as the second does and that selenium is eliminated more rapidly from the system than tellurium.

In 1909 the study of Gadamer led to the conclusion that the toxic action of selenium is analogous to that of arsenic and that seleniuretted hydrogen is highly irritant when inhaled and may even cause pulmonary oedema in animals.

Amongst the other compounds, *seleneous acid* (*H₂SeO₃*) is, according to Gadamer, highly toxic, for it causes lowering of the blood pressure, vomiting, diarrhoea, paralysis of the central nervous system, convulsions and death.

*Selenic acid* (*H₂SeO₄*) is said to exert an action less intense than the above compound.

A. Hamilton relates that in 1917, when visiting a large American copper foundry, she collected information relative to several cases of poisoning by selenium. The symptoms in question were bronchial irritation and digestive derangements noted amongst workers engaged in crushing selenium-bearing ores. The selenium was eliminated by precipitation in the form of sulphate, but the melting process was considered the most dangerous operation for the workers (dust, fumes). The workers attacked complained also of pains in the abdomen, in the lumbar region, vomiting and colds with sore throat and fever. The garlic odour of the breath lasted for a long time even after work had been given up. These phenomena were, however, not common.

It should be recalled further that in the course of massive poisoning due to beer containing selenic acid (Great Britain, 1901) other symptoms were noted, such as paresthesia, erythromelalgia and melanosis (arsenic?).

Selenium and its compounds are not found on any list of *compensation*. Nevertheless injuries due to these substances may receive compensation in those countries which possess a very general formula, e.g. U.S.S.R., etc. (see article "Occupational Diseases: Definition and Compensation").

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Seleniuretted Hydrogen

Seleniuretted hydrogen (symbol $\text{H}_2\text{Se}$) is a colourless gas, analogous to sulphuretted hydrogen, which is soluble in water. When burnt, it yields selenium, and precipitates various metallic solutions.

It is very toxic, according to Babu-teau, reducing the haemoglobin in the blood, to which it gives a deep red colour. The gas is eliminated by a current of oxygen, and a broad band of absorption between D and E in the spectrum takes the place of the band of oxyhaemoglobin.

Inhalation produces painful sensations of pricking on the nasal mucous membrane (attributable to the decomposition of the gas with deposit of selenium), then repeated sneezing efforts, which become tiring. The sense of smell is affected and may disappear for some days. Subsequently, too, there is headache and cough.

Statistics of poisoning relate solely to occurrences in the laboratory, such as those described at Göttingen. Berzélius, who studied seleniuretted hydrogen, is said to have suffered from the effects of the gas.

The processes of dosage and research are similar to those for sulphuretted hydrogen.

Shale Oil Industry


A well-defined group of skin lesions has been found to be associated with the processes of distillation and refining of mineral oils. These conditions have been the subject of careful observation in the Scottish shale oil industry for a number of years, and much work has been done with the object of lessening their frequency and severity. Any consideration of the pathological conditions due to employment must necessarily be accompanied by a short description of the processes of distillation and refining of oils, as some of these are more directly associated with pathological conditions than others.

Process

Oil shale, which exists in practically unlimited quantities below the lower coal strata in the west and Mid Lothian Districts of Scotland, is got by mining in a similar way to that in which coal is obtained. After being broken into small pieces in powerful breaking machines, it is fed into large vertical retorts which are heated partly by waste gases got from the distillation of shale, the temperature being maintained at approximately $1,900^\circ$ F. in the lower portion and $900^\circ$ F. in the upper portion of the retort. The oil gases are distilled from the shale in the upper portion, while the nitrogen of the shale is given off at the higher temperature, and in combination with steam passed through the bottom of the retort; part of this nitrogen forms ammonia gas. Another part of the nitrogen combines to form organic compounds (organic bases) known as amines, viz. pyrrol and series and pyridin and series. The gases are drawn into condensers where they condense into ammonia liquor and liquid oil, which by their different specific gravities separate and are drawn off into different tanks. The ammoniacal bases — amines — condense along with the liquid oil and are contained in the oil as organic nitrogen compounds known as the pyrrol and pyridin series. The incondensable gases are used for heating the retorts.

After the gases have been distilled from the shale, the refuse, known as spent shale, is discharged from the bottom of the retort into a hutch (wagon) underneath and conveyed to a waste heap. The ammonia liquor is distilled and the gases are treated with sulphuric acid, forming sulphate of ammonia, which need not be considered further as far as this article is concerned.

The condensed oil is known as crude oil. This is delivered into tanks which feed by gravitation into boilers (still) where the lightest fractions of oil, ultimately forming naphtha and burning oil, are distilled and condensed. The oil now left is distilled in dry gas, leaving a solid residue in the still, known as coke, which being rich in carbon forms a valuable fuel.

The gases from the heavier oils condense and form “crude distillate”. This crude distillate is run into tanks in which it is first mixed with sulphuric acid and then with caustic soda, removing the tarry contents of the crude oil; the nitrogenous compounds are at this stage eliminated by the sulphuric acid, passing off with the acid tar. At this stage, therefore, both tars and nitrogenous compounds are eliminated from the crude distillate. The acid is recovered and goes back for further use in the process; the tar is used as fuel. The acid is used for combining with ammonia gases to form sulphate of...
ammonia. The heavy oil left is now technically known as "green oil". This is re-distilled; the distillate is cooled by anhydrous ammonia, forming a pasty mixture of oil and crystals of paraffin frozen out of the oily solution. This mixture is pumped through filter presses. Up to this point workmen never come into intimate contact with oils, tar or other chemical substances, these being confined to the vessels in which the processes are carried out. By means of filter presses some of the oil is separated, leaving semi-solid cakes of paraffin, known as "paraffin scale". Filter presses consist of long iron frames about 3½ ft. high, with numerous iron plates arranged vertically, with coarse canvas filter cloth between each, through which the oil is filtered from the scale, the oil running off and the scale being retained between the iron plates. Workmen pull the plates apart at intervals and separate the scale from the filter cloths with scrapers. The scale drops into conveyers to be carried off for further treatment.

Fig. 112 and 113 show working attitudes of the men, and it will be noticed that the arms and hands are in more or less intimate contact with the oily scale.

The scale is now taken to the hydraulic press department, where it is packed into cloths laid on trays, the scale being shovelled into cloths and levelled with the hands and forearms. This process is more responsible for pathological conditions than any others.

The trays are then placed in hydraulic presses, vertical frames about 8 ft. high, with numerous shelves, and as the higher shelves are being filled, the workmen's arms are held above their heads and oil trickles down the forearms.

The legs and feet also get wet with oil. The departments in which the scale is filtered and put into hydraulic presses are known as the "crude paraffin departments or green sheds". After the oil is expressed by hydraulic power the trays are emptied, and the hardened wax left in filter cloths on trays is sent to the refining sheds ("sweating sheds"), where the last of the oil is sweated out by steam heat. The expressed oil is known as "blue oil". During the whole process in green sheds the workmen are daily in intimate contact with crude paraffin and oil, accounting for all of the pathological conditions met with among paraffin workers.

After exposure to steam heat in sweating sheds, the paraffin is now refined, and after a final purification with charcoal or other substance, is fit for commercial use. The oil separated in filter presses and hydraulic presses goes through the same processes, being re-treated with acids and soda, cooled and again filtered and pressed as before. The subsequent treatment of the oil, dividing it into the various grades of lubricating oil, etc., need not be considered here, as in no other stage of the entire process other than those already described are work-
men affected with any of the typical papular, pustular or erythematous lesions.

A diagram of the entire process of manufacture of sulphate of ammonia, mineral oils and paraffin wax from oil shale is given on page 832.

**PATHOLOGY**

**Occupational Dermatoses**

The skin lesions due to contact with oily paraffin in a crude or semi-refined state may be described as conforming to the following types, of which one only, or several, may be found on the same individual:

1. Occupation comedones.
2. Folliculitis and peri-folliculitis.
3. Dermatitis pustulare.
4. Dermatitis papulare (Erythema papulare).
5. Erythema simplex.
6. Dermatitis erythematosa (Erythrodernia).

These, which include all forms of occupational eruptions met with in the
Scottish shale oil industry, will be briefly described under their various heads.

(1) Occupation Comedones

These occur in parts exposed to contact with paraffin products, especially over flexures of elbows, posterior aspects of elbows, upper aspects of shoulder joints, and occasionally over knees. Their origin is purely mechanical, being due to obstruction of sebaceous ducts with semi-solid paraffin substances. They are larger than comedones met with under ordinary conditions, more closely packed together and confined to circumscribed areas, being most prevalent on the anterior aspects of body and limbs. They are easily expressed. There is little tendency to acne formation, as the materials obstructing the ducts are sterile. After they have persisted for lengthened periods, some tendency to acne may be seen. On ceasing work among paraffin substances, they
readily disappear if regularly expressed, and do not develop further, but are apt to recur on resuming similar employment.

(2) Folliculitis and Peri-Folliculitis

This is one of the most prevalent forms of skin lesion occurring among paraffin workers. It consists of destruction of the hairs and hair follicles as the result of a mild inflammatory reaction set up by mineral oils. The follicles become somewhat dilated and filled with epithelial debris and dirt, so that they appear as closely grouped clusters of black points, corresponding to hair follicles, over the parts affected. Occasionally a slight peri-folliculitis occurs, in which the inflammatory condition extends to the surrounding skin, which becomes slightly raised above the level of the rest of the skin tissue, and ultimately becomes hardened and thickened. The most common sites are the backs of fingers and hands, and to a less degree the forearms and legs round the ankles, and dorsal aspects of toes and feet, especially on the line of the extensor tendons of toes. There is never any tendency to sloughing or suppuration; the condition persists as described indefinitely. The appearance of dryness of hands, with clusters of black points on backs of fingers, is typical among paraffin workers.

(3) Dermatitis Pustulare

This is not a prevalent condition. Two types have been noted:

(A) One in which the condition is characterised by the appearance of numerous small pustules over the anterior aspect of body and limbs, and

(B) One in which the pustular eruption is due to the breaking down of the typical papule which is the most common form of occupational eruption.

(A) Primary pustular dermatitis. — A widely distributed pustular dermatitis occasionally occurs among youths beginning work in the paraffin departments. The pustules are small, each being surrounded by a slight inflammatory areola, and are mostly found on the anterior aspect of limbs and trunk. The channel of entrance of the irritant appears to be by the hair follicles, as generally a hair is found in the centre of each pustule. This type readily disappears on removing the individual from this particular form of work. The tops of pustules get dry and are shed as crusts, without further return.

(B) Papulo-pustules. — These occur on the sites of papules, the pus for-
ing at apical part of papule. These as a rule are not numerous and are usually seen in conjunction with a papular eruption. They are due to the breaking down of a papule from strepto- or staphylo-coccal infection, or to the separation of a small necrotic area from the centre of the papule, after which the papulo-pustule disappears.

(4) Dermatitis Papulare (Erythema Papulare)

This is by far the most common form of lesion met with among paraffin workers, approximately between 40 and 50 per cent. of the men being affected, the majority of these having only a few papules. These papules are known in the trade as "paraffin plukes", and are typical of an occupational eruption both in history and distribution. Papular dermatitis consists of an eruption of small rounded elevations of a purplish colour, varying in size from that of a small pepper corn to that of a small pea. They are solid, superficial, rounded in shape and contain no fluid. Frequently there is a minute central depression, from which a tiny core can be expressed or removed, and which corresponds to a necrosed hair follicle or sebaceous duct. Workmen affected try to pick out this core, after which the papule heals. The entrance of irritant is by the sebaceous ducts, but frequently the hair follicles are involved, in which case a hair occupies the central position in a papule. There is as a rule no inflammatory areola round a papule; there is never itching or irritation; they do not coalesce and as a rule heal spontaneously.

It has been frequently noted during the routine examinations that the sites of papules vary from time to time, some healing and others developing in different situations. Papules may be present in two's or three's or in larger numbers till there may be a diffuse eruption, but the majority of those affected show a few papules only. The distribution of the papular eruption is typical. In the great majority of cases it is confined to the forearms, being most pronounced over the ulnar aspects, though it is also prevalent over anterior and posterior aspects of forearms, round wrists and on backs of hands. Less frequently a few papules are seen on shoulders, legs and dorsal aspects of feet. They are frequently seen behind elbows. The palms of hands and soles of feet are never affected.

The earliest appearance of papules is seen in about twelve days after beginning work in paraffin sheds. They disappear a few days after ceasing work in that department. In old-standing cases, the papules, instead of heal-
ing, develop a warty hardness, forming scaly warts, gradually becoming harder and more indurated. These warty papules tend to persist indefinitely. In the most chronic types these warty papules may increase in size, with the formation of a central necrotic area, which may slough and separate, being followed by the healing and disappearance of wart, with scar formation. At a still more advanced stage the warty papule breaks down and forms an epitheliomatous ulcer.

(5) Erythema Simplex

This consists of a mild hyperaemia, in which the redness is distributed generally over parts affected. The first appearance is a slight blush, followed by a greater degree of redness which at first disappears on pressure, reappearing on withdrawal of pressure. This hyperaemia is practically always limited to forearms, and is associated with a dryness of the skin. Later the erythema becomes purplish and remains on pressure, with permanent pigmentation of skin. This condition may persist for years without alteration. The affected parts become scaly, and usually show a shiny appearance. This type of lesion usually exists alone without the presence of any other form of eruption.

(6) Dermatitis Erythemalosa (Erythrodermia)

This is essentially a dermatitis of a sub-acute or chronic type, due to prolonged action of oily paraffin on the tissues of skin. It represents a further extension of an erythema, in which the congestion gradually merges into a chronic inflammation of the various layers of the epidermis and cutis vera, followed by induration and, in the most advanced stages, by partial or complete destruction of small areas of skin in the affected parts. In the first stage the lesion consists of dull red patches distributed irregularly over the anterior aspects of forearms, either linear or roughly circular in shape. These are slightly raised above the surface of the skin, are dry and somewhat scaly. As the condition becomes more chronic, larger areas are involved, the whole of the forearms being affected. Pigmentation is usually seen in conjunction with this condition. This erythematous stage may persist for long periods, or healing may take place, the redness disappearing, and being replaced by induration of the superficial layers of the skin, with a permanent scaliness. Frequently the dermatitis progresses so that the deeper layers are affected, and, as the inflammation becomes more chronic, scars appear, white in colour, varying in depth according to the depth of the
inflammatory changes. There is a more or less constant tendency to the formation of small warts, usually oval or circular in shape, raised above the level of surrounding skin. These warts are dry and scaly. In advanced cases the whole surface of the forearms appears indurated, hard and thickened, giving a leathery appearance — sometimes called shagreen skin. The scaly warts are typical of old standing dermatitis, and go on proliferating long after cessation of working with paraffin materials. Once this stage has been reached, the hyperplasias go on, sometimes large warts being seen. These warts may still continue to proliferate and grow larger, ultimately breaking down and forming epitheliomata. Chronic dermatitis usually co-exists with old standing papular dermatitis, in which the papules are of the indurated type, hard and warty. Thus, in an advanced stage, the forearms show pigmented patches, white areas of scar formation, scaly or horny warts, and indurated papules, any one of which at any time may take on features of malignancy, depending entirely on “the personal factor”. The distribution of this type of dermatitis is confined to the lower halves of arms, the forearms, and to a lesser extent, the feet.

(7) Epithelioma (Paraffin Workers' Cancer)

Epitheliomata as seen among the paraffin workers of the Scottish shale oil industry occur only in those about or over middle life who have been so employed for twelve years or more. They usually arise from warts due to a chronic dermatitis or from indurated papules, both already described, and therefore may co-exist with an advanced dermatitis, in which wartiness is a predominant feature, or with numerous papules of a simple nature, of indurated type. The usual appearance is that of a gradually growing epithelioma, in the midst of an indurated dermatitis, with a number of warts or indurated papules, only one of which has become malignant. It is not uncommon for workmen to have several different growths at various times, but there are never two malignant growths at one time on the same individual. The warts or papules have been as a rule present for a number of years in a benign form, until the epithelial covering begins to proliferate more rapidly, with increasing growth of the primary lesion, gradually assuming the features of a malignant condition. These epitheliomata have been seen most frequently among those who have been paraffin workers for from twelve to thirty years.

Epitheliomata also occur among retortmen, stillmen, and labourers in oil works, quite distinct from the group of paraffin workers. These men do not
come into such intimate contact with oils and crude paraffins in their work, and so do not suffer from any of the papular or inflammatory lesions which occur among the paraffin workers. On these workmen an epithelioma arises as a reddish pea-shaped nodule, in which the typical cell nests are present practically from the onset. There is epithelial proliferation accompanied by the degenerative changes associated with an epitheliomatous growth. The scrotum is most commonly the site of such lesions, possibly due to the difficulty of ensuring cleanliness of this region.

Of all cases of paraffin workers epithelioma recorded in connection with the Scottish shale oil industry over the last twenty-eight years, the incidence was found to be 0.5 per cent. per annum among the paraffin workers proper, and 0.1 per cent. among the other oil workers. Among the paraffin workers, 63 per cent. of the occurrences were on arms, forearms and hands, 20 per cent. on face and legs, and 17 per cent. on scrotum, while among the oil workers the proportions were reversed, viz. 58 per cent. on scrotum, and 25 per cent. on hands, arms and forearms. These figures show that among oil works labourers the tendency is for epitheliomata to occur more frequently on scrotum, while among paraffin workers proper the tendency is for hands and forearms to be more frequently affected.

The important aetiological factors in production of epitheliomata are age, length of service, and idiosyncrasy or predisposition. Seventy-five per cent. of the total number of epitheliomata have been contracted over fifty years.
of age; 80 per cent. have occurred after fifteen years of service. Approximately half of the paraffin workers have some form of dermatitis, yet all are equally exposed to contact with oils, and of those affected only a very small proportion develop malignant conditions.

**Hygiene**

During recent years a great deal has been done for the protection of workmen in the paraffin departments of this industry, by means of baths, medical examinations, and protective applications. In all the works where refining of oil and separation of paraffin wax is carried out, baths are provided for the workmen. A description of one such building will suffice to give an idea of the provision made. The bathroom is a large airy, well-lit room, about 55 ft. long, 15 ft. broad, and 12 ft. high, adjoining the paraffin sheds. It is lined internally by glazed tiles, and is heated to a comfortable heat by hot air pipes. At one end are four hand basins fitted with hot and cold water; above each is a metal container filled with neutral liquid soap. At the other end of the room is a large steep bath, with clothes wringer attached for washing socks and clothing. On one side are five upright spray baths, lined with glazed tiles and fitted with hot and cold sprays, each having in addition a deep foot bath. On each side of a spray bath is a cubicle for one man to be getting ready while another is washing. On the fourth side, along wall and across floor are arranged forty lockers, fitted
with pegs for clothes, shelves for boots, wires for towels, the lockers being heated by hot air pipes passing through the bottoms. Seats are provided beside the lockers. Each workman is provided with a weekly supply of soap and towels for his own use. The baths are kept spotlessly clean by attendants. On ceasing work, the men bath daily, and put on their outdoor clothes. They wash their socks and hang all their working clothes in lockers to be dried and ready for use next day. The workmen are all supplied with heavy canvas aprons to keep the clothes as dry as possible. Before working, each man smears his hands and arms with commercial castor oil, which has been found to withstand the solvent action of paraffin better than anything else. A large jar of this is kept handy, and occupational and otherwise. Charts are used for recording conditions noted, for permanent record and for comparison with former records. The results of the examinations are very satisfactory, as conditions which might prove serious are got at the earliest period. During the last ten years, twenty small epitheliomata have been discovered and removed without recurrence. In no other way would it be possible to ensure correspondingly good results. The conditions of the men, as noted at each examination, are divided into several groups, as follow:

Group 1: those free from occupational eruption;
Group 2: those having a few papules or slight erythema only;
Group 3: those having a slight degree of any form of eruption and limited in extent;
Group 4: those with extensive eruptions of any type;
Group 5: those showing any condition approaching malignancy.

For permanently recording conditions found at each examination, different coloured crayons are used for each condition, so that the chart relative to each man shows clearly his condition. For those men who have been occupied for long periods in paraffin sheds, these charts form a valuable three-monthly record as to their progress; the same also applies to those recently employed, or who have been paraffin workers for shorter periods. In the cases of new employees, if after beginning work they

Fig. 128. — Steep basins.
are found to be extensively affected with papular dermatitis, and if this does not gradually improve substantially after a few examinations, these men are removed from that particular occupation, as being unsuited for it. In this way a selective process is continually going on, so that at the present time the personnel of the paraffin sheds is composed of: (a) a proportion of old employees who have been workers there for many years, and (b) a larger proportion of younger men who have been selected as showing little predisposition towards eruptions due to contact with paraffin. The whole cost of this inspection is borne by the employers, who help in every way in furthering the complete scheme as being in the best interests of the workmen.

LEGISLATION

In Great Britain section 73 of the Factory and Workshops Act, 1901, requires notification of all cases of epitheliomatous ulceration due to mineral oil and paraffin to the certifying factory surgeon for the district.

By order of the Secretary of State (Statutory Rules and Orders, No. 1775, 28 November 1929), the provisions of section 73 of the Factory and Workshops Act, 1901, were made applicable to epitheliomatous ulceration due to mineral oil and paraffin. This came into force 1 January 1920, thus making this condition a "scheduled trade's disease" from that date.

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Shoddy
(Mungo)

French: Laine régénérée, laine renaissance artificielle. — German: Kunstwolle. — Italian: Lana meccanica, rigenerata, artificiale; — Spanish: Lana mecanica, recopuesta.

Several qualities of this product are known. Shoddy is made by unravelling waste from combed wools and merinos, etc.; mungo made by picking to pieces rags and fulled cloth (these two types of material are subjected to slight "gassing" in the factories); alpaca wool made from rags of mixed materials — not pure wool (the wool is separated by means of chemical processes: carbonising by hydrochloric or sulphuric acid or chlorides; this is followed by drying at a rather high temperature (from 65-130° C.) and heating to eliminate the carbonised matter)

Amongst apprentices and those new to the trade there has been noted in the rag-cutting workrooms and those in which the wool is freed from vegetable matter the occurrence of an affection designated "shoddy fever" and cutaneous lesions and lesions of the mucous membrane caused by the acids.

See also article "Rags".

The legislative measures issued in regard to rag picking are superfluous where rags are damped, washed and freed from grease before handling.

For hygiene and legislation, see article "Rags". For vegetable wool, see article "Kapok".

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Silicon

French and German: Silicium. — Italian and Spanish: Silicio.

Silicon (symbol Si) is one of the most abundant elements in nature. Combined with oxygen, it forms silica (silicic dioxide, SiO₂). It enters into the composition of quartz, the amethyst, the agate, the opal, and numerous kinds of sand. In the state of silica it constitutes the principal constituent of the most important rocks. It was prepared in a pre-amorphous state by Berzelius (1823) by heating felsicarbonate of potassium with metallic potassium.

At the present time it is prepared in considerable quantities by reducing quartz with wood charcoal in an electric furnace, with the addition of CaO and MnO. The crude silicon obtained is purified by hydrochloric and hydrofluoric acid, and the final product contains 90 to 91 per cent. of Si.

It is also prepared by heating silicon fluoride with metallic sodium and by bringing to red heat powdered quartz in the presence of powdered magnesium. There is often found in crude iron from blast furnaces, free silicon derived from the reduction of silica by carbon.

Amorphous silicon is only soluble in hydrofluoric acid (with liberation of hydrogen) or in alkaloids. It is a bad conductor of electricity, and burns with liberation of SiO₂ when heated in the air. Crystallised silicon is a good conductor of electricity, of a hardness exceeding that of glass, does not dissolve in any single acid, but only in a mixture of nitric and hydrofluoric acid.

It does not become oxidised even when brought to red heat in an oxygen atmosphere. By boiling it in a solution of caustic soda, it dissolves, giving off hydrogen and silicate of soda. It melts at 1,439° C. Amorphous silicon heated to a high temperature acts like crystallised silicon; burned in an atmosphere of chlorine, it forms silicon chloride (SiCl₄). It enters into combination with iron at an ordinary temperature; at a high temperature it combines with nitrogen, and in an electric furnace with various metals for the formation of silicides.

From experiments of Glaser and Roll (1926) on silicon rendered free from silica, it has been shown that there exist stable modifications characterised by certain physical properties (thermic analysis and caloric dilatation). From the fact that silicon enters into the composition of iron, cast iron and other metallic preparations ("duralumin", "silumin" and "alpax"), the experiments of Glaser and Roll encourage the expectation of the preparation of materials of construction of a stable form.

The principal silicon combinations are:

Silicon hydrogen (SiH₄), a colourless gas with a disagreeable odour, subject to spontaneous ignition; silicon tetra-chloride (SiCl₄), used as a war gas, causes, during decomposition, caustic burning of the ocular and respiratory mucous membrane; bromide and iodide of silicon (SiBr₃ and SiI₃), silicon fluoride (SiF₄): colourless smoking gas with a piquant smell and harmful to the respiratory system and to vegetation. Mass poisonings due to this gas have been reported by Egli in a chemical factory; fluorsilic acid (SiF₄) — see
article "Hydrofluoric Acid"); silicon carbide (SiCl), a product commonly known as "carborundum". Carborundum is prepared in the electric furnace at a temperature slightly below 2,200°C. Raw materials utilised are silicious sand (34 per cent.), coke (at least 90 per cent.) carbon (35 per cent.), sawdust (7 per cent.), sea salt (2 per cent.).

According to Willis, silicon carbide dusts exercise no effect whatsoever on susceptibility to tubercular infection of the lung amongst animals which have been treated by injecting subcutaneously virulent virulent bacilli; calcium suicide (SiCa₂) used for reducing and desulphurising metals; iron suicide (see article "Ferro silicon"); dioxide of silicon (SiO₂) abounds in nature in the form of crystallised quartz in hexagonal pyramids, generally without cleavage. It serves in the manufacture of laboratory apparatus made of quartz, in the manufacture of quartz glass, and, in powdered form, in the preparation of cleaning powders, of paints, and in foundries, etc.

Manufacture of silicon glass has undergone special development recently as a result of progress made in the use of the electric furnace. Silicon glass, also known as molten quartz, contains 99.5 to 99.8 per cent. of silicon. It is obtained from pure silicon sand by melting in an electric furnace in the presence of carbon electrodes. During this operation there occurs liberation of silicon and carbon monoxide at about 1,400°C, whilst at a temperature of 1,600°C, the silicon liberated is in a state of fumes, and burns above the furnace, giving white silicon smoke. At this temperature silicon fumes may be freely disseminated and become condensed.

Quartz rocks, which serve in the preparation of silica, are subjected to grinding in grinding mills. The industry is a fairly restricted one. Middleton (1930) has reported a fatal case of silicosis with tuberculosis affecting a worker engaged in these mills in the north-west of England.

There should, in conclusion, be mentioned oxide of silicon (SiO), silicate acid (SiO₂H₄), silicon disulphide (SiS₂) and silicon nitride (Si₃N₄).

Silica has been found amongst the numerous constituents of the human system by Schmidt, in 1909, in normal urine.

Research by Spica on the action of soluble silica injected into rabbits would appear to have proved the existence of a harmful effect. Kunkel (1901) denies any toxic action from silicic dioxide, whilst Lewin (1903), as likewise Erben and V. Jacksch, attribute to silicon the presence of chronic catarrh of the mucous membrane of the respiratory passages, the occurrence of chalciosis, and other pulmonary lesions, upon which tuberculosis readily supervenes amongst workers in the granite industry, emery industry and amongst stone cutters.

At the present moment numerous research agents have demonstrated in a conclusive fashion the harmful action of silica on workers exposed to inhalation of dust from this product (see article "Tuberculosis and Silicosis").

Mazzi and Sgai (1913) found punctate basophilia in the blood of workers engaged in the glass industry. Having succeeded in eliminating the possibility of the action of lead compounds, the two authors were led to the conclusion that the harmful agent in question was silica, which opinion was corroborated by evidence of a slight increase in the silica content of the urine. Subsequent to laboratory research, these authors arrived at the conclusion that sodium silicate should be considered as a blood poison, fairly potent in the case of rabbits. Pure silica (silicious earth) constitutes an anaemia-producing agent less violent than sodium silicate. Pure amorphous silica given in very large doses causes serious anaemia in the case of rabbits, with, however, more retarded appearance of the symptoms (about twenty days) than in the case of impure silica. Silicon tetrachloride appears as an anaemia-producing agent, and its capacity for destruction of the red cells is fairly considerable.

Mazzi and Sgai have completed their experimental research by investigations conducted amongst masons and former glass workers. They found in the blood of these men alterations similar to those observed in animals (more marked anisocytosis, chlorotic red cells in a fairly considerable number, slight increase of chromatophile red cells, whilst four-fifths of the cases showed basophile red cells: increase of lymphocytes and slight diminution of the number of red cells and of the total haemoglobin). In the urine the silica content was increased in four-fifths of the cases. This increase was in proportion to the number of years of working experience and to the presence of punctate basophilia in the blood. Mazzi and Sgai have con-
cluded that silicon, and especially the silicates, diminish the organic resistance of workers to disease, and weaken their means of defence. The damage in question consists of cellular lesions of the tissues, and especially alteration of the blood with destruction of the red cells. There is a state of chronic poisoning having the appearance of toxic anaemia with basophilic granulation, accompanied by some polychromatophile cells, a certain degree of leucolymphocytosis and diminution below 1 of the haemoglobin count.

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Silk


In the year 2698 B.C., Si-Ling-Chi, the wife of the emperor Hoang-Ti, invented the art of breeding silk-worms, and of reeling the cocoons in order to obtain the silk thread. Unreeled silk has been used by the Chinese from the most remote time for the manufacture of musical strings and fishing lines.

Since the introduction of silk-worms into Europe by two monks belonging to the Order of St. Basil in A.D. 551, the manufacture of silk has given rise to an industry which, still at the present time, comprises one of the chief sources of wealth in the countries which have encouraged its development. This industry includes two phases: (1) breeding the silk-worm, and (2) spinning the silk.

The silk-worm (Bombyx mori) can adapt itself to the most varied conditions of climate and soil; but it is chiefly the countries with a temperate climate where the thermometer does not fall below 20° C. during the breeding time which are best adapted for sericulture. One of the results of cultivating the silk-worm is that it has lost a good deal of its natural resistance; so that it is necessary to ensure the most careful hygienic conditions during its short larval period: rational incubation of the eggs or seed, and keeping the surroundings hygienic the raising ground. There are special firms nowadays which only concern themselves with the preparation of the eggs. After having selected the cocoons which are to be allowed to turn into worms, the breeder carefully supervises the placing of the insects and the laying of the eggs. On an average 100-125 moths are needed to obtain about 30 grm. of eggs; in a mass of this weight there are from 45,000 to 55,000 eggs. These are examined under the microscope, which permits the elimination of sterile and infected products, and ensures the selection of only good quality and healthy eggs. They are then preserved in closed boxes placed in cellars or refrigerators, in order to avoid sudden variations of temperature. The hatching of the eggs takes place in peasants' houses, or in silk-worm nurseries in Provence. A mechanical incubator is often used in order to hatch the eggs at a convenient moment, carefully related with the development of the mulberry tree, the leaves of which form the silk-worms' food.

The silk-worm (magnan) lives for forty days, during which time the temperature and the degree of humidity must be most carefully watched, as well as the feeding, the bedding and the skin casting of the silk-worm. At the end of this period it looks for some point of support upon which to hang its cocoon; therefore the next thing is to provide the silk-worm with little branches of wood arranged slantwise.

At the end of about a week all the cocoons are formed. The produce of the nurseries is collected by the establishments where the reeling takes place; here the chrysalis is killed in stoves by means of a current of air heated to 50-91° C. In certain cases the hot air is replaced by steam under pressure. For some time past chloropicrine has been used, the quantity being 1 grm. per kilogram of cocoons. When the cocoons are spread out on screens in the fresh air all smell of chloropicrine passes off. This process does no harm to the silky covering, interfering neither with the colour nor the quality of the newly formed cocoons, nor does it affect the spinning.

After being killed, the cocoons are reeled. This operation is preceded by soaking the cocoons in a round deep basin in water heated nearly to boiling point (the scalding process) and by beating, the object of which is cleaning, i.e. the removal of the superficial silky covering of an imperfect texture, from which is derived the silk thread called floss. The reeling of the thread is carried out in reeling basins, containing water at a temperature of about 60° C., a special apparatus being used composed of a shank which curves backward and forks at the upper end, and of a reeling frame. The woman worker passes in and out of the branches which are at the end of the branches of each shank, windable threads from
two or more cocoons; the movement of the reeler sweeps off the silk from the cocoons, which are fastened to the reeler by their free end. Silk thus obtained is called raw or crude. When the gum which covers it is removed, the silk is said to be scalded or scoured.

Before being woven, the silk thread goes through various spinning processes, which include: reeling the hanks; the transfer of the silk on to bobbins; twisting, which is applied separately to each thread coming from the bobbins; doubling two threads of raw silk already either twisted separ-
ately or not; twisting applied to the double thread; a fresh reeling on to bobbins; and the formation, by a fresh twisting, of threads arising from the collection of two or more threads of raw silk.

The hanks derived from drawing the threads from the cocoons are first of all sprinkled with soapy water in vats, where they are left for twenty-four hours to make them supple and elastic. All the operations take place in workshops where the temperature varies from 20 to 25° C. and the relative humidity from 60 to 80 per cent.

After this the silk is sent away to be woven. It can be dyed before or after being woven.

The lustre is imparted to silk when it has reached the stage of being a soft and uniform fabric. After being calendared and brushed, the silk acquires a shining surface by being treated with a solution of formic acid at 90 per cent. and a solution of celluloid, nitrocellulose and viscose or acetocellulose. The formic acid makes the silk swell out and become gelatinous. After being washed and stretched, it is treated with celluloid in a solution of 25 per cent. in alcohol at 94 per cent.

The solution is applied by brush, and evenly distributed by means of two rollers. The drying process follows.

When acetocellulose is used, it is in solution with phosphate of triphenyl (used to prevent fire) and triacetine as an adhesive, with the addition of such volatile solvents as alcohol and tetrachloride of carbon.

For bleaching silk, sulphur dioxide is used in an aqueous solution or in solution with bi-sulphite of soda. After elimination of the gum, the silk may be exposed in a room to fumes from burning sulphur. If the bi-sul-
phite is used, the silk is passed into vats containing the solution. But hydrosulphite of soda may also be used, followed by a wash bath and bath of hydrochloric acid or of oxygenated water, which must be hot, followed by an acid bath and a neutralisation bath. The method of using peroxide of soda and sulphuric acid is the least costly.

The silk-worm gut used in surgery and for fishing is obtained by taking the silk-worms which are ready to spin their cocoon and immersing them in vinegar. In Spain vigorous silk-worms are selected, and are prevented from climbing to the twigs of wood to hang their cocoon there; they are killed by being plunged into nitric acid solution or vinegar. Skilled women workers open the dead silk-worms and draw out the two serigenous glands, situated one on each side of the digestive tube. The silk-worm gut, after being carefully dried, is then washed in alkaline water. For surgical use the silk-worm gut has the two imperfect ends removed and is sterilised.

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STATISTICS

There are few up-to-date statistics available relating to the health of women employed in raising silk-worms. Among spinners the general morbidity is not very high. Celli found a percentage of 13 among 206 women workers at one filature, amongst whom the various kinds of morbidity were represented by: general illnesses, 2.4 per cent.; respiratory diseases, 15.0 per cent.; nervous diseases, 0.5 per cent. In the course of a detailed enquiry made by Carozzi in 1910, 193 spinners who were medically examined were found to be suffering from (percentages): general illnesses (including anaemia), 6.33; respiratory diseases, 4.66; digestive diseases, 4.66; nervous diseases, 0.33; diseases of the genital organs, 0.66; infectious diseases (especially typhoid fever), 15.33; eye disease, 0.99; and other diseases, 2.97. The high incidence of typhoid fever was not connected with the occupation; it was the reflection of an epidemic that was raging in the district.

PATHOLOGY

There is no record in the available literature of any particular illness among the women employed in raising silk-worms which can be directly attributed to the occupation, except possibly asthmatic attacks of an anaphylactic character, due to the scaly dust produced by the fluttering of the moths' wings when they are mating.

Disorders which can be classed as
occupational have, however, been noted among spinners, apart from respiratory disease, anaemia, or, in certain cases, conjunctivitis, which are found to affect all categories of workers obliged to work in warm and damp surroundings. Investigations made by Correnti in 1912 only served to reveal the existence of disorders of the blood characteristic of anaemia and chlorosis, which he attributed particularly to physical exhaustion, to work in hot, damp and close surroundings, and to bad feeding. Women employed at the reeling basins complained, especially in the past, of menstrual trouble due to the uncomfortable positions they work in, and to the effect on the abdominal organs of the heat of the stoves on which the water for the basins is heated. Troubles connected with the sensibility of the hands were reported by Crocco in 1910; but nothing definite was noted, and further investigation on the subject is desirable (Carozzi). But more often deterioration of the skin of the hands, which has the appearance of being macerated and is erythematous, may be found. This condition is especially found on the right side; but it cannot be considered as characteristic of the occupation (Carozzi).

The silk workers' dermatosis or "basin disease" (mal des bassines), described by Potton in 1853, which was regarded as of serious importance in days gone by, has almost disappeared at the present time. Carozzi states that out of 300 women workers examined, he only came across 9 cases of ulcerations about the nails (3 per cent.) and 3 cases of phlegmon (1 per cent.). J. H. Fabre, who discovered the irritating character of, and isolated a special virus from, the body and excrement of the bombix, did not in any way connect the existence of this poison with "basin disease". He showed that the troubles attributed by the Provençal silk-worm raisers to poison from the silk-worm, i.e. red and swollen eyelids, attacks of violent itching, with exfoliations of the epithelium of the forearm, were caused by the dust of the dried excrement of the silk-worms, and by contact of dirty hands with the face. F. Heim in 1904 and Pautrier, referring to Potton's research work, have described two kinds of dermatosis: (i) "silk-worm disease", due in the silk-worm rearing houses, to contact of human skin with excrement from the silk-worms, and (ii) "basin disease", possibly of similar etiology, which appears in the form of ordinary lesions due to macerations in the hot water of the basins, and as specific lesions. In the opinion of these experts, the

![Fig. 128. — One of the earliest filatures in Lombardy.](image)
hypothesis of a parasitic acarus cannot be accepted, for the irritant property is to be found in the normal healthy chrysalis. By rubbing chrysalis powder mixed into an ointment on the skin, the dermatitis has been experimentally reproduced. The lesion is said to be aseptic if protected from any secondary infection, and thus only the first of the three stages of the malady results.

The high temperature of the water in the basins, the mechanical action of the silk thread and the chemical action of the various substances, such as gum, grit and wax, which are in the cocoons when scalded, also contribute their part in the pathogeny of this lesion. But the importance of personal cleanliness must not be overlooked, nor, primarily, individual predisposition. In the most serious cases the dermatitis is the starting-point for other infections, the origin of which must be looked for outside the occupation, e.g. in domestic work. The reelers suffer from lesions on the hands which come and go, and are very variable, such as small ulcers that are round and crateriform, caused by the friction of the bottom of the basin during the beating of the cocoons; a small callosity on the right index due to erosion by the silk thread; callosities on the palm of the right hand, due to the pressure arising from the "escoubette" a small circular broom used for beating the cocoons as they float in the basins (Carozzi). Warts are often observed. In their writings Goldberg (1926) and Vedroff (1927) confirm the existence of these various cutaneous affections among the reelers of cocoons.

Neither are there any up-to-date data on the pathology of the weavers of silk. Birwitzky (1927) examined 400 women employed in throwing silk, and found some comparatively mild forms of catarrh of the respiratory tract, due to rhinitis and laryngitis. He also reported undefined disturbances, which he connected with the noise and vibration of the workshops he visited where the reeling and throwing of the silk took place.

Fig. 129. A modern filature in Italy.

The "shuttle kissing" found among cotton spinners is unknown among silk workers (Elton).

In an article written for the Industrial Fatigue Research Board (1922) on the subject of the psychological and physiological qualifications needed for weaving, Elton comes to the conclusion that a weaver should possess good sight, power of observation, skill in the use of both hands, a sensitive touch, and endurance when standing.

For weighting silk, lead is often used and also tin in the form of the phosphate, which takes the place of tetra-chloride of tin. Lead is fixed on to the silk as the oxide or phosphate or a
combination of the two. But it is a fact that in practice other salts of lead are used, such as the acetate, which is cheaper.

Finally, it is essential to recall the fact that lead may be extracted from the silk by the solvents used in dry-cleaning processes.

In 1912 Teleky drew attention to the risk of lead poisoning incurred by workers and persons who use silk from the weighting and the dyeing of the silk when such salts of lead are used as the acetate. From 100 kg. of silk, up to 4-5 kg. of waste were obtained, containing as much as 42 per cent. of acetate of lead.

Unfortunately, it has not been possible to consult several Chinese and Japanese contributions on the subject of the hygiene and pathology of women employed in the silk industry of those countries.

Cases of eczema caused by wearing silk under-garments have been attributed by S. J. Taub (1930) to a protein in the silk capable of causing non-specific asthmatic reactions. It is essential that fresh investigations should be made on this point.

Atmosphere is inadequate, there will obviously be a considerable condensation of steam, with the formation of a thick mist. In summer all that is necessary is good airing or natural ventilation; but in winter the difficulties become great, because it is necessary to introduce large quantities of warm, dry air into the building. The floor of a filature must be made of good material, fairly thick and warm, but not entirely impermeable. Drains covered with a grating must be provided for waste water. It is a good thing to have adequate space under the roof. If the building has a

Hygiene

In places where silk-worms are raised, the strictest cleanliness must be enforced, and hygienic measures must be taken to ward off disease from the silk-worms and to protect the women workers from unhealthy conditions of work.

The premises of a filature, where spinning is carried on, must be of dimensions in proportion to the importance of its plant. This refers chiefly to its floor space and height. For, if the building is too high and if the heating of the upper layers of the

Fig. 130. — A modern filature in Japan.
glass roof, there should be sliding panes which can be opened. It is better to avoid placing a cocoon filature on the ground floor; it is advisable to have it on the first floor, with the plant for producing heat and power on the floor beneath.

Avoid all great radiation of heat, and also the formation and unchecked discharge of steam into the air.

The rational and effective solution of the problem of doing away with steam is to limit its diffusion into the surrounding air; so it is necessary to catch it at its source, discharge it outside, and replace air saturated with humidity by dry, warm air. Of course, with water which is kept constantly at boiling point. After this preparation the cocoons pass into other basins, called reeling basins, filled with water at a temperature of about 60° C.

In some filatures the same basins have to serve as accessory and as reeling basins, so that all these preliminary operations take place in the same vessels, only, of course, the temperature of the water has to be lowered for the reeling.

In order to prevent the discharge of steam, filatures having separate accessory basins provide closed-in exhaust hoods, through which there are openings for introducing or removing the

Fig. 131. — Another modern filature in Japan.

the changing and the warming of the air must be regulated in order to keep the surrounding temperature from becoming too high. It is also quite a good thing to keep the interior of the building under slight positive pressure or at a pressure that is equal to that of the outside in order to prevent the formation of cold currents by air coming in from without.

As has been seen, reeling is necessarily preceded by the preparatory work of scalding, beating and cleaning. For these operations the cocoons are emptied into a special basin filled cocoons. This exhaust system allows for the evacuation of the steam.

When the work is not thus divided, the problem is more difficult. Some employers have recourse to reeling basins fitted with apparatus for evacuation. The arrangement consists of a double basin with an exhaust cover. This double basin consists of a round basin, which rests on the basin bench and contains water heated by means of a steam pipe going to the bottom of the basin. A ring-shaped cover fits exactly over the round basin and rests on the basin bench. An interior basin

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called a "bassinette", round-shaped and widening out at its upper part, rests on the cover; its bottom and sides are pierced with holes, through which the water from the round basin enters. The upper part of the bassinette, which is widened out and crown-shaped, is pierced with two rows of holes, through which the steam escapes, only to be sucked up by an exhaust column adapted for each basin and opening into a collector surmounted in the centre by a main upcast chimney for evacuation.

Thermometers and psychrometers should be provided, in order to control the temperature, which should be maintained at about 23° C. (dry), while the humidity should not exceed 70-80 per cent.

The water in the steam-heated basins should be renewed frequently; used chrysalids should be removed; and the accumulation of waste liable to putrefy, or of fetid water, should be forbidden.

Water that has been used for scalding and washing should be emptied into a drain, without giving it a chance to decompose; it must never be emptied on to the roads, nor used for watering the land. The chrysalids and the solid waste from the manufacture must be removed daily, where possible, and in any case very frequently, and should be taken to the open country and buried deep, or else taken to special factories to be changed into manure.

These conditions must also be insisted on in the treatment of floss from the cocoons, i.e. in dealing with the residue obtained during the reeling operation, as well as with cocoons which have been pierced, and constitute the material used in the manufacture of flock silk and certain other stuffs.

After having been freed by maceration from the gumming substance with which they are impregnated, these residues are dried, beaten, combed, carded and finally spun. The residuary water from these manufactures is extremely liable to ferment.

Maceration of the skin in the early stage may be prevented by smearing the hands and fore-arms with a hydrofuge paste.

Whereas the problem of natural lighting is generally simple, because the buildings more often than not have a double row of windows or a glazed roof, much consideration, on the other hand, must be given to the placing
of lights for artificial illumination. It is advisable to see that the lights are placed alternately on the two series of basins, so as to cross and integrate the illumination on the working posts adequately. The use of 1/4-watt lamps of 400-600 candle power is to be recommended; for it is of value from the double point of view of hygiene and industrial economy. On account of the high degree of humidity, a well-insulated electric system must be provided. The workers' ordinary clothes must not be worn in the spinning mill. Cloakrooms, properly warmed in winter, should be provided. Working clothes must be made of flannel. A sufficient number of lavatories should be provided supplied with hot and cold water; and also privies which do not expose the workers to sudden changes in temperature.

When Asiatic countries become industrialised, the transformation of little workshops in isolated villages into factories takes place under varied conditions of hygiene. The provision at filatures of factory dormitories, in China for instance, is an example of progress. The special committee of the Japanese Association for Social Legislation, when studying in 1927 the protection of women working in silk filatures in Japan, put forward a resolution demanding the reduction of the working day to eleven hours, improvement of the sanitary conditions in factories and dormitories, and the strict application of medical examination, with notification of diseases.

**Legislation**

Boys under sixteen and women under twenty-one are excluded in Spain from reeling cocoons; in France young men under eighteen; in Italy boys under fifteen and women under twenty-one are excluded from opening and heating the residue from the silk where adequate exhaust ventilation for dust removal is not provided.

There is no special legislation for the silk industry, but in Japan reeler's dermatitis is compensated.

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**Silos (Work in)**


From the time of the construction of the first silo in 1875, their use has become more and more widespread, with the result that conditions of work in them are of ever-increasing importance.

The former type of warehouse consisted of silos hollowed out in the form of a ditch, a system which presented grave danger from the accumulation of heavy gases. The modern type comprises a construction above the level of the ground, generally in wood, masonry, reinforced concrete or metal, provided with a roof and furnished with doors at the sides. During the filling of the silos with products to be stored, which are driven back by a current of compressed air, the workers are sometimes engaged in heaping up the goods which arrive by way of the piping. Metallic silos are erected on concrete foundations and comprise a central part
or tower and accessory parts; the roof, the storing pipe or blower and the small discharge turret or aperture. The degree of airtightness required for protection against acids of fermentation is provided by the use of cement inserted between the sheets of metal. An anti-rust paint is applied to the outside or it is subjected to a metal spray. In the inside, a paint with an asphalt basis or an enamel with a bakelite basis is used.

In large silos, especially in ports, modern technical methods involve the use of mechanical apparatus for transport and loading of the products. In very large plant, facilities exist for withdrawal of dust by exhaust from the goods (wheat, meal, etc.) and their transmission to the storing chambers.

In the flour-milling industry, storing in sacks is increasing in use. Here storing is also effected mechanically and automatically, and the silos are constructed in such a way as to prevent heating and the liberation of disagreeable smells.

**Sources of Risk**

Two sources of risk are involved by this work: inhalation of dust and asphyxiation by carbon dioxide liberated as the product of intramolecular alteration of the vegetable products. As regards the first danger, research has been engaged in by Tedeschi and Abbo in Italy.

Experimental research conducted with a view to acquiring knowledge of the various germs contained in these dusts (exposure of guinea-pigs to dust from silos and to artificial dusts mixed with bacilli of active tuberculosis) have revealed the fact that the anatomical-pathological lesions caused by the dust from silos chiefly affects the upper parts of the respiratory tree, the pulmonary tissue remaining almost intact. Nevertheless there has been noted a chronic hyperplastic inflammatory process of the interstitial tissue. The anatomical lesions caused by inhalation of the dust containing tubercular bacilli did not differ to a remarkable extent from those caused by natural dusts. It was concluded, therefore, that dusts coming from silos only favoured to a limited extent the development of pathogenic microbes.

Asphyxia due to carbon dioxide represents a further risk for workers in silos. A number of agricultural periodicals have drawn attention to this danger, which has likewise been reported as constituting a risk for workers occupied in the holds of ships transporting grain, and also for workers employed in peat trenches.

The composition of the air at the time of filling the silos is exactly similar to that of the normal atmosphere, but as soon as the forage is introduced the free oxygen in the air consumed by the fermentations is replaced almost volume for volume by carbon dioxide. An analysis of the air even during the first twenty-four hours often shows complete disappearance of free oxygen. The nitrogen concentration generally remains unaltered. Increase in the initial temperature noted in the silo is due to the intramolecular respiration of the vegetable cells increased by the respiratory surfaces of the cut plants. The liberation of harmful gases increases during a period of two days when the carbon dioxide produced becomes mixed with the residual nitrogen of the atmosphere. The carbon dioxide given off is a product of the life-process of the vegetable cell and not of a fermentative action due to micro-organisms developed subsequent to storing in the silos (Hayhurst and Scott). Carbon dioxide also acts as a preserving agent in the silo, and loss of it would be prejudicial to the merchandise. In general the mould only attains the surface of the silo. The carbon dioxide rate of development in a silo filled with green corn may attain 75 per cent. of the total gas present, the greater part of the remainder of the gases being constituted by the nitrogen of the atmosphere.

An analysis of a sample of gas from a silo gave the following figures:

<table>
<thead>
<tr>
<th>Gas</th>
<th>1st analysis (percentage)</th>
<th>2nd analysis (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>38.0</td>
<td>38.3</td>
</tr>
<tr>
<td>Oxygen</td>
<td>13.5</td>
<td>14.0</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>48.5</td>
<td>57.7</td>
</tr>
</tbody>
</table>

No reaction led to detection of carbon monoxide, ammonia, hydrocyanic acid or methane.

Workers who enter silos containing coal dust are also exposed to a danger of poisoning.

**Pathology**

Examination of a certain number of workers working under the above conditions has revealed frequent incidence of injury to the respiratory apparatus, notably bronchial affections and processes of broncho-pulmonary-sclerosis. Amongst workers employed in subterranean chambers there has been noted general weakness, anaemia, loss of weight and muscular strength, signs of incipient broncho-alveolitis with de-
finite sclerotic foci. Nevertheless, examination of the sputa was negative as regards the Koch bacillus. It must be remembered that these workers live under specially adverse conditions (unhealthy dwellings, etc.) which are far from being adequate and are distinctly unfavourable from the health point of view.

Hayhurst and Scott reported for the first time four fatal cases which occurred at Athens, Ohio. It is possible that accidents of this kind may have already occurred, their origin being probably attributed to other causes. The cases reported occurred under the following circumstances: by means of a ladder placed against the outside of a metal silo, four workers opened a door which was at a height of about 3.50 metres and entered the silo by jumping to the bottom, which was at a height of about 2 metres below the level of the door. Five minutes later two other workers climbed the ladder, and stated that the first four workers were lying dead on the ground. By entering the silo by a lower door it was possible to remove the asphyxiated men, who were completely cyanosed and had ceased to breathe. In the case of three, some cardiac movement seemed to remain. Efforts at artificial respiration and restoration of life were without success. In a few minutes all four were dead. Apart from accentuated cyanosis of the lungs, the mucous membrane, the trachea and the bronchial tubes, congestion of the liver and kidneys, congestion of the capillaries of the brain and intestines, no other important lesions were found. The heart and blood vessels showed no injury.

The silo had been filled with green corn from a recent harvest, the temperature in the interior was about 3.77°C above that of the exterior atmosphere. A guinea-pig, a rabbit and a dog exposed successively lost consciousness after a period of respectively 30 and 60 seconds and 23 minutes. The guinea-pig died in 10 minutes, the rabbit in 42 minutes. The dog, withdrawn after a period of 33 minutes, regained consciousness after 6 minutes and was completely restored without artificial respiration. A member of the enquiry who put his head into the silo at the level of the corn suffered a pricking and burning sensation in the nose and smelt an odour recalling that of alcohol. Another member of the enquiry found similar fumes at the level of the lower part just above the corn and experienced irritation of the mucous membrane of the throat for a period of 15 to 20 minutes. Experience proved that toleration was rapidly acquired as regards this type of disagreeable effect, with the result that often the workers exposed do not even notice it.

Workers in silos may be exposed to injuries to the skin and mucous membrane, especially the eyes, caused by grain and parasites present therein. (See articles "Agricultural Labourers" and "Flour Mills").

**HYGIENE**

Danger from asphyxiation in silos is considerable and exceeds that encountered in other occupational groups such as cellarmen, vineyard workers, brewery and distillery workers, manufacturers of yeast and vinegar. Thoroughgoing measures of precaution are in consequence indicated. Doors placed immediately over the level of the products stored in the silos should be left open or provided with hinges allowing of automatic functioning in accordance with the settling of the products stored. Suppression of roofing has been advised, which would have for effect the provision of draughts for favouring the removal of the gas. Nevertheless, the best means of prevention consists in the utilisation of a candle or lantern prior to entering the silo. Extinction of the light provides information as to dangerous diminution of the atmospheric oxygen.

Where explosion is feared, experiment may be made by lowering a mouse or small bird.

In case of accident, artificial respiration should be applied as quickly as possible and oxygen administered for inhalation. The incidence of a fairly high proportion of respiratory affections amongst workers in silos, and, on the other hand, the unfavourable action exerted by dust from silos on the health point to the need for prophylactic measures such as medical examination of the workers prior to engagement and periodical medical examination thereafter, with a view to the timely detection of signs of incipient respiratory disease.

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Silver


Properties

Silver is a very white metal, fairly soft, and when polished is beautifully bright. Its symbol is Ag.; its atomic weight, 107.88; specific gravity, 10.5; melting point, 960° C.; and boiling point, 1555° C. (with the escape of blue vapour). Molten silver absorbs twenty-two times its volume of oxygen, and at the moment of solidification there is a sudden evolution of this gas which causes the metal to spurt in a characteristic way (the rocketting or "rochage" of silver).

It does not oxidise in contact with air, but becomes blackened in the presence of very slight traces of sulphured hydrogen, owing to the formation of sulphide of silver. It dissolves in cold nitric acid, becoming nitrate of silver, accompanied by an escape of nitrogen dioxide. Silver is very slightly attacked when cold by other acids, and not at all by alkalis.

The soluble salts of silver are precipitated from solution as the white chloride of silver by the addition of hydrochloric acid or chlorides — the reaction characteristic of silver.

Production

Mines. — The richest silver mines are in Australia and Mexico; there are also important mines in the United States, Bolivia, Peru, Chile, Saxony, Norway, France, and Silesia.

The ores worked are very various: native silver, argyrose (sulphide of silver), argyrythrose or red silver (double sulphide of antimony and silver), proustite (double sulphide of arsenic and silver), polybasite (sulphide of copper, silver and antimony), etc., which are properly described as ores, for they are treated for the silver itself. There are also numerous accessory minerals such as pyrites and argentiferous galena, which supply silver in addition to the metal for which they are treated (see articles "Copper", "Lead" and "Zinc").

The processes used for the ores, properly so called, vary much, according to the richness of the ore and the resources of the country. They may nevertheless be grouped as follows: (a) treatment by lead or materials containing lead; (b) treatment by mercury or the amalgam process; (c) treatment by the wet method.

(a) The ore mixed with lead or litharge, galena, red lead, or waste products from desilverising works is heated to 500° C. in a cauldron or kettle (four à manche). The dress which forms on the surface of the liquid is skimmed off. In this way working lead is obtained which is desilverised by ordinary methods (see article "Lead").

(b) The amalgam process is always carried out in the American mines by the cold process, as fuel is scarce. The ore is broken by hand into small pieces of 2 to 3 centimetres, riddled whilst dry and pulverised between granite grindstones with water. The product thus obtained is spread upon a paved floor (the patio) where it is mixed with common salt, the whole being incorporated by being trodden out by mules. Some days later "magistral", i.e. roasted copper pyrites, is added and then mercury. Chloride of silver is first formed and thereafter the amalgam. At the end of fifty days the mud is washed away by a flow of water; the amalgam is collected, filtered and distilled. The addition of hyposulphite greatly hastens the reaction, which then only lasts four days.

Amalgaamation by heat is employed mostly in Europe. The process called "val process" (aux tonneaux) is employed in Saxony. The ore when crushed, ground and roasted with common salt forms chloride of silver, whilst any arsenic and antimony present in the ore volatilise. The mass is ground and passed into revolving vats with water, iron and mercury. The amalgam collects at the lower part. Any excess of mercury is separated by filtering through chamois leather. The process is also carried out in coppers or pans in which the roasted ore is heated with common salt, water and mercury. During every operation the mass is actively stirred. Then the amalgam of silver is distilled, usually in a vacuum.

(c) The Augustin process (Freyberg) transforms by roasting the sulphide of silver into sulphate; a second roasting with common salt gives chloride of silver. The mass is then washed with a concentrated solution of common salt, which dissolves the chloride of silver. The metal is precipitated from its soluble state by copper, which is regenerated by iron.

It is also possible to proceed by dissolving the sulphate of silver directly and precipitating by copper.

The process of Patera-Russell used in California is only a variant of the preceding process. Chloride of silver, obtained by roasting, is dissolved in a solution of hyposulphite of sodium and then precipitated by sulphide of calcium and common salt. The hyposulphite of soda is regenerated with the formation
of sulphide of silver, which is filtered, dried, and roasted with lead. The argentiferous lead is then cupelled.

In Mexico, the cyanide process tends to replace the mercury process for extracting silver from poor quality ores. In this process the ore is treated by a solution of cyanide of sodium, kept in movement by aerial agitation. A soluble double cyanide of sodium and silver is formed from which the silver is separated by precipitation by passing the solution over zinc filings. The silver is collected in filter-presses, washed, and melted with borax and carbonate of soda.

In order to obtain fine silver, raw silver obtained by one of the processes referred to above should be again refined, either by cupellation (see article "Lead") or by electrolysis of a nitric solution of silver nitrate. The anodes are raw silver and the cathodes leaves of pure silver. Various devices are provided for detaching the crystals of silver which keep forming and are liable to cause short-circuiting.

**Use**

Pure silver is only employed for making crucibles and pans, used in the chemical industry for the preparation of alkalisi. An alloy of copper and silver is always used for the manufacture of jewellery, plate, coins, and other articles. "White metals" are alloys of silver, copper, nickel and zinc.

Among the salts of silver it is sufficient to mention the bromide and the nitrate, which are the most used in industrial processes. They are used not only in pharmacy, but also in the preparation of photographic plates and printing paper, and in silvering (see article "Electroplating"). The silvering of mirrors is carried out by heating a soluble silver salt with a reducing agent: the metallic silver is then precipitated on the glass. Silvering by heat is now very little used.

A very unhealthy employment is that of black engraving or Tula work; a preliminary incision made by machinery upon the surface of silver articles is filled with a powdered and melted mixture of copper, lead, sulphur and silver. Any excess of the black mass of Tula material is removed by glass paper, whilst the small quantity of sulphide of lead formed during the process is partly oxidised into a soluble compound of lead. The silver is blackened by the help of arsenic, by plunging into a bath formed of arsenious acid, sulphate of iron, concentrated sulphuric acid and fine zinc filings.

Arseniuretted hydrogen is then liberated; whilst in other baths a liberation of cyanogen may occur.

The making of silver leaf, which is generally done by hand (see article "Gold"), and the making of silver nitrate pencils by evaporating a solution of silver nitrate, are both injurious. The crystals obtained are crushed, sifted and melted into moulds in the form of pencils.

**Sources of Poisoning**

The occupational risks of workmen employed in the metallurgy of silver are represented not only by inhalation and contact with the metal, but also by inhalation of vapours of lead, mercury, arsenic, and tellurium, as well as by such poisonous gases as carbon monoxide, compounds of cyanogen, and arsine.

Miners and metallurgists are also exposed to the action of mineral dust containing the products above mentioned (lead, arsenic, tellurium, etc.). Further, it is necessary to take into account the risks arising from changes of temperature (sickness due to cold).

**Toxic Action**

The dust of metallic silver or its salts, once absorbed, reach the circulatory system and become changed into albuminate of silver, which is deposited in the tissues; it is still a matter of discussion to-day whether the absorption takes place through the digestive or respiratory systems, or by way of the skin. The state of the digestive apparatus may sometimes render it difficult to eliminate the silver absorbed. Nitrate of silver changes in the stomach into the chloride, and probably also partly into albuminates, which are eliminated by the stools or absorbed by the intestine.

When once the compound of silver arrives in the tissues, it is precipitated in the metallic state and becomes fixed in the tissues in a form which cannot be eliminated. This takes place either by the action of light, e.g., the skin of the hands, of the face and of visible mucous membranes, or by reduction, by means of sulphuretted hydrogen, in other tissues.

**Statistics**

Cases of industrial argyrisms are quite rare and cases of generalised argyrisms are still rarer. Though Pauluzzini noticed a particular coloration of the skin among silver workers.
Koelsch collected in 1912 a certain number of cases of occupational argyrysm, among which he mentioned those which came under his personal observation among working women who cut silver leaves and arranged them in books. Other cases have been reported among working women employed in preparing pencils of silver nitrate.

There may be recalled here a case of Jung's (1909) with grey coloration of the conjunctiva; three cases cited by Reuss (1897) among photographers who presented a localised staining of the carunculae iridum; five cases mentioned by Noble, as well as the case reported by W. Jones (1907), refer to persons employed in the extraction of the metal by the cyanide process.

Teleky (1914) recalls the two further cases of Schubert and Lewin in making silver nitrate pencils, and mentions cases reported by himself among workers who made silver nitrate pencils, and among the workers in the Isergebirge district where heads made of silvered glass are manufactured, at Goblonz and Morchenstein. The making of glass heads of gold, silver, or changing colour, gave employment to about 2,000 workers for the most part at home. This work was carried on as far back as 1796. The silvering of the beads was obtained by employing an alloy of lead and tin. In 1894 Ledetsch had already drawn attention to the existence of forty to fifty cases of argyrysm among workers, but it was only in 1910 that an enquiry was held by Teleky, which revealed about ten cases of which only five were of recent origin.

The cavity of the blown bead is filled with a solution of silver nitrate (1 per cent.) containing a little caustic potash and common salt. After clarification lactose is added to accelerate the reduction of the silver. Before 1910 this solution was introduced into the bead by the mouth, but a section of workers even then employed a small india-rubber tube for this purpose; to-day the process is invariably effected mechanically.

Besides the cases reported by the industrial clinic at Milan, must finally be mentioned the very recent cases of Subai (1922, Germany), of Adamson (1924, Great Britain), and of Maranon (1924, France).

**SYMPTOMS**

The deposit of silver causes a special blue coloration (blue men) which may be localised or general.

Blue spots appear upon the face, the carunculae iridum, the buccal mucous membrane, and especially upon the hands (the left by preference) of workers with silver, either the metal or its salts. The facts that the upper parts of the body are most affected (probably because they are less protected against the action of light than the lower parts), and that the buccal cavity presents a very intense coloration, are characteristic.

The existence of a line on the gums is a good deal disputed. Teleky, for example, does not admit it, at least in the form which has been described by Lionville. Other experts hold that at the beginning a small grey line is formed which may also occur on the free borders of the eyelids and around the nails. This line, noticed among persons who have been following a treatment with a base of silver, has not however been observed among workers.

Similarly various opinions are held upon the general troubles caused by silver. While A. Schmidt speaks of toxic catarrh of the digestive tract, R. von Jaksch states he has never observed any interference with the digestive functions, or dyspepsia, and considers that if these troubles do exist, that they ought to be ascribed to other co-existing toxic influences. In the cases of silver poisoning reported by Agasse-Lafont among photographers, examination of the blood has established an unusual number of mononuclear cells.

Spots of silver salt upon the skin are easily recognised because they are not removed by sulphuric or hydrochloric acids.

**DEMONSTRATION**

Silver may be detected without difficulty in the urine. Mayencon and Bergeret propose the following process: soak in the urine a little cylinder of zinc or of magnesium around which is wrapped a thread of platinum. The silver is deposited little by little upon the platinum. This line is made visible by plunging it for some seconds into an atmosphere of chlorine or of nitric acid vapour. The thread of platinum is then rubbed upon white paper moistened with ammonia. The deposit of silver appears black if the paper be then moistened with a solution of sulphuretted hydrogen.

**LEGISLATION**

In Argentina women are excluded from polishing precious metals (silver, gold). In France young men up to eighteen years of age are excluded from the refining of gold and silver by acids in workshops where fumes escape and acids are manipulated. In Italy boys under fifteen years and women under twenty-one years are excluded from refining precious metals.

In Spain boys below sixteen years, and women below twenty-one years are excluded only from places where fumes escape or where acids are handled. See also articles "Lead", "Mercury", "Arsenic", etc.

Special measures are insisted upon particularly in lead foundries which also
Skin Diseases

Skin diseases constitute at the present time an important chapter in occupational pathology, ranging from light erythema to epilimbioma and including a whole series of intermediate injuries, at times designated by the expression "Dermatosis traumaticus". Where the eruption assumes the form of a dermatitis, folliculitis, ulceration, or cancer, such a term is quite suitable so long as the causative agent is added. Where the causative agent is uncertain, it is essential to qualify the word "dermatosis" by the addition of the words "occupational", "industrial", "extrinsic", "traumatic", or "exogenous". The lesion will then be differentiated from an analogous cutaneous disease similar in type but of internal unexplained or unknown (i.e. idiopathic) origin. Characterised by accidental occurrence, in general of a persistent or recurring nature, occupational dermatoses are of considerable importance from the social and hygienic aspect. With the exception of cancer they do not endanger life, but they may nevertheless gravely affect health, giving rise to long periods of incapacity for work.

Certain of these cutaneous lesions were already referred to by Galien, Paracelsus and Agricola (sixteenth century), but it was Ramazzini (1700) who was the first to enumerate in a precise and systematic fashion the principal forms of occupational dermatosis affecting bakers, millers, fruit peelers, laundry workers, shoemakers, tailors, horsemen, sailors, etc., thus bringing to light the importance of certain etiological factors. Nevertheless, it was not before the end of the eighteenth century that general attention in the medical world was directed to these forms of dermatosis (Pott, Willan, Bate-man, Thackrah, in Great Britain; Alibert in France; Cazenave, Schiedel, Halfort in Germany, etc.), and thereafter, more especially since the end of the nineteenth century, and particularly during and since the war as a result of the development of the manufacture and use of chemical products, increasing attention has been bestowed on this problem. Thanks to the numerous studies existing at the present time, forms of occupational dermatoses are better understood than formerly, and it may be anticipated that they will become, in all probability, a diminishing factor of occupational risk, since their causes are generally evident or readily discerned. Recognition of these and the recent development of pathogenic theory have facilitated the application in the case of cutaneous affections of adequate methods of prevention which are at times simple and straightforward.

Etiology — Pathogenesis

Occupational dermatoses depend on the action of irritant agents (causative factor), as well as on reactions peculiar to the skin (accessory factor).

Irritant Agents

Accidents occur when the intensity of the irritation exceeds the limits of resistance of the skin, or when the stimulation lasts over an unduly long period. The duration of the action, the close contact, certain mechanical factors, the nature and solubility of the stimulant, etc., constitute several special factors which must all be taken into consideration. The various reactions of the skin to a given product may at times depend on varying composition or presentation of the product (its origin, method of production, etc.). In the majority of cases a product must produce a direct action on the skin various products must produce a direct action on the horny layer (burning, maceration, dissolving) or a destructive or colloidial chemical action on the protoplasm of the cells of this layer. Certain toxic substances, however, pass intact through the horny layer (tar derivatives, etheral oil, iodiform, orthoform, resorcin, pyrogallic acid, naphthol, naphthalene, aniline, and azo colouring compounds, certain vegetable substances, quinine, chrysarobin, etc.).

It is impossible, on account of their multiplicity and diversity, to provide a systematic and rational classification, not only of all the physical, chemical and biological agents likely to cause occupational dermatosis, but also of the trades and processes in which these sources of danger are encoun-
tered, and equally impossible to enumerate the operations involved.

Attempts to do so have, however, been made, and reference to these will be limited to the classification made by Prosser-White and based on the physical, chemical or biological affinities of the causes of morbid conditions:

1. **Mechanical or physical agents:** Cuts, pricks, abrasions, friction, pressure, crushing, tearing. Mass effects such as the action of solids, liquids or fumes, either in molecular form or in subdivision.

2. **Detergents:** The action of which consists in a washing of the skin, generally with softening or solution of the horny layer (maceration): hot water, soap, light alkalies (soda, turpentine and its substitutes); all substances which emulsify skin lipoids increase the irritant action of other chemicals: cotton seed oil, olive oil, alcohol, phenylene bases, aniline and many aromatic hydrocarbons which dissolve the skin cholesterol and enable the former to penetrate.

3. **Desiccators and anhydrides:** Hydroscopic bodies, sulphurous, sulphuric, nitric and phosphoric dioxides. These products absorb water and generate heat in forming their respective strong acids: potash, soda and strong alkalies; ammonium nitrate, caustic lime, calcium chloride, calcium nitrate, hypochlorites including the hypochlorides; nitric and sulphuric acids.

4. **Hydrolysers:** These unite with one or more molecules of water to form separate compounds, usually more simple: chlorides of organic compounds (for example dichlorehyl sulphide, which in the presence of water liberates chlorine ions to form hydrochloric gas), borocain (splits into boric acid and cocaine), ammonium nitrate (splits into nitric acid and ammonium), phosgen (splits into hydrochloric acid and carbon monoxide). Hydrolysis causes liberation of energy which stimulates the sensitive nerve endings, and the consequent reflex brings about dilatation of the blood vessels, capable of developing into erythema, swelling, phlyctenules and necrosis (W. E. Dixon).

5. **Protein precipitants:** These are all irritants: all the heavy metal salts (Cuschny), formaldehyde, most acids (tannic acid, picric phenic acid, etc.).

6. **Oxidisers:** Nitrates in the presence of acids, chlorine and its compounds in the presence of water, free iodine and its preparations, the hypochlorites including "bleaching powder", ferric chloride, peroxide of hydrogen, chlorate, potassium, nitrate of potassium, nitric and sulphuric acid under certain conditions, pure potash and soda, ozone, persulphate of soda.

7. **Reducers:** splitting water with liberation of hydrogen: These agents in weak solutions are often keratogenic (kerato-plastic) stimulating cornification; in strong concentration they act as keratolytics: tar, pyrogalol, most free and all finely divided colloid metals, formalin, paraphenylenediamine, phenol, resorcin, sulphur dioxide, hydrosulphites and sulphides, carbon monoxide, arsenious oxide (combines with oxygen to form arsenic acid), bismuth: and meta-phenylendiamine, phenyl in the presence of oxidising agents.

8. **Free acids in salts or forming toxic nitro derivatives:** Nitro-hydro carbon derivatives, trinitrotoluene, dinitrobenzene, tetryl, picric acid.

9. **Keratogenic and neoplastic agents:** Arsenic, certain distillations of bituminous coal, petroleum and shale oils, aniline, certain radiations.

10. **Biologic agents:** Effect of vegetable and animal agents on the skin and tissues (micro-organisms, parasites).

11. **Sensitizers:** Favoring constitutionally changes of the skin and bringing about a more intense or violent reaction in response to a further application of the former agent:

   (a) **Anaphylactoid agents** (Hanzlick): chemical products: haematoporphyrin, aspirin, benzene molecule in 606, iodine, mercury, phenylhydrazine.

   (b) **Anaphylactic agents** (Richet) set up antigenic reactions; vegetable proteins (legumes, cereals, flour, pollen); or animal proteins (milk, eggs, feathers, scales, flesh).

The various products met with in industry exercise mostly a mixed action and there is a certain difficulty in determining at what point chemical action ceases and physical action commences, etc. Nevertheless, it is the chemical action which is predominant in inducing the outbreak of forms of occupational dermatoses, though in regard to the majority of these products the precise mechanism of their action is still obscure. The origin of these troubles would appear to be less complicated in the case of those which present the medical-legal aspect of an occupational accident. It is then a question of direct or more or less distant consequences of an accident (injuries caused by projection of chemical substances as a result of accidental breaking or splintering of receptacles, piping, etc.). In the most obscure
cases it is a question of more or less retarded complications where dermatoses are due, apart from the primary agent, to complications caused by excessive recourse to medicaments (peroxide of hydrogen, iodine, picric acid, irritating ointments) or to rapid or delayed infection of wounds. The complications of pathogenic agents may be further manifested by superimposed varicose ulcers, the development of blastomyces, trichophytosis, sporotrichosis, etc., on the parts of the skin exposed to recurring traumatism. These same traumasisms may favour localisation of certain infectious lesions (anthrax, malignant pustule, anatomic tuberculosis, syphilis). Finally, idio-pathic dermatoses or dermatoses of internal origin (psoriasis, purpura, certain types of scleroderma) may occur as a consequence of certain traumasisms (Aievoll).

Skin Resistance

The strength and elasticity of the healthy skin make it resistant to mechanical injury of average extent, as well as to many noxious fluids and powders. On the other hand, the various layers of the skin possess specific resistance with regard to the action of certain harmful factors. Thus the horny cells are unaffected by a 50 per cent. solution of mineral acid and pepsin. The kerato-hyaline of the granular layer is insoluble in alcohol, ether, chloroform, weak acid and alkalis. Boiling water is harmless to the spongioplasm of the tactile cells. Certain agents, however, readily destroy the cellular elements of the skin. The horny layer is soluble in weak solutions of potash, soda, milk of lime, alkaline earths and sulphides. Eudelin is rapidly destroyed by formalin, sublimate, acids and alkalis; the last disintegrate the spongioplasm and saponify the cholesterol and liquid waxes which form the protecting secretions of the sebaceous glands.

The openings to these, the hair follicles and the furrows on the skin's surface are its most vulnerable points. They constitute accordingly the points of origin of most if not all cutaneous troubles by reason of accumulation of oils, chemical powders and noxious liquids. It is at these points that bacteria penetrate, and it is there also that bites and stings of insects succeed in injecting poisons or pathological agents into the blood.

The skin is, however, to a greater extent than any other tissue subject to individual reactions, which it is necessary to take into account in ex-plaining the excessive resistance or sensibility of certain workers in regard to various dermatoses.

Modern research tends to support the conclusion that individual characteristics of the skin are dependent on the glandular equilibrium of the individual on various endocrine derangements or nutritional disturbances likely to set up highly varied reactions. Deseaux even goes so far as to consider the epidermis as an immense endocrine gland and seeks to establish on the basis of the chemical reactions which take place within the deep-seated epidermic cells and the dermic cells a pathogenic theory relative to cutaneous accidents. Hyper-sensibility — recalling anaphylactic phenomena — may be monovalent or polyvalent according as to whether it is a question of one or several substances provoking the reaction. In certain cases the limited areas of the skin present a special sensibility and even where it is a case of a product with a general action (absorption of a substance through the mucous membrane or the digestive or respiratory passageway) the phenomenon becomes located on a sensitised area of the skin. This fact has been experimentally demonstrated by allergic reaction of the sensitised dermic cells with regard to a given irritant applied to persons insensitive to this irritant. According to the products which may bring about an outbreak of the anaphylactic syndrome, it is possible to foresee what occupations would constitute exposure to these risks.

At times certain subjects, who for many years have enjoyed natural immunity as regards a certain harmful agent, contact with which has been more or less continuous, suddenly at a given moment develop, for a quite inexplicable reason (nutritional disturbances or derangement of the endocrine system, etc.), sensibility to the noxious agent.

As a rule, sensibility of the skin occurs after a delay which it is not possible to determine accurately, but it may be very brief. Once acquired, a very slight quantity of the product in question may set up extremely serious injury. In the case of certain substances, the intervention of an accessory factor such as light is essential in order to bring about sensiveness (anthraquinone, acridine, anthracene, pellagra, etc.).

This sensiveness of the skin may be diminished or intensified by various constitutional factors: age (immature skin of youth and the atrophied skin of age are particularly sensitive), sex.
SKIN DISEASES

which were of occupational origin. Gardiner (1919), among 1194 cases, 870 of
accordance with variations in the system of classification. It is placed at 1 per cent. by Finch Noyes,
and referring to the various organs (kidneys, digestive system, nervous system, etc.). The importance of these
factors has often been emphasised by various authors and as regards occupational accidents it has been noted that
their development is accelerated by several months in the presence of seborrhoea and several weeks where
there is excessive perspiration (Gardiner).

It is essential also to take into account the fact that in certain cases, subsequent to a slight initial attack of
dermatitis, there set in a period of acclimatisation of the skin to the harmful agent. Finally, it should be stated
that the skin injuries after a first attack of dermatitis may persist even after withdrawal from the action of the
harmful product.

Prof. Prosser White
(Manchester).

STATISTICS

At the present time the literature relating to occupational dermatoses is extensive, and the references are very numerous. But the evaluation of these statistics is not easy, because there has to be taken into account the influence of the personal factor, as well as the particular qualification needed for making a diagnosis. Speaking generally, it may be said that most statistics either over-estimate, or under-estimate, the etiological influence of occupation.

The proportion of occupational dermatoses in relation to all dermatoses is assessed differently by different authors. It is placed at 1 per cent. by Finch Noyes, at 2 per cent. by Fordyce (1911), at 4 per cent. by Lane, at 6 per cent. by Prosser White, at 7.5 per cent. by Gardiner, and even at 18.5 per cent. by Knowles (1913). This percentage may, however, be higher when the statistics deal with a period of observation not exceeding one year; it is 22 per cent. according to Oppenheim, who studied 2,040 cases of dermatoses in 1912; 25 per cent. according to Prosser-White, in a group of 250 patients; 57 per cent. according to Oppenheim (1928), among factory workers, the subjects of an investigation; 72 per cent. according to Gardiner (1919), among 1,194 cases, 870 of which were of occupational origin.

As regards eczemas, very variable rates have been given, the occupational origin being quoted sometimes at a third and sometimes at a quarter of the total cases observed.

Some Austrian figures dealing with a period of thirteen years, from 1907 to 1922, but not including the years 1911 and 1917, and relating to 27,500 cases of dermatoses give, according to Oppenheim, 20 per cent. as of occupational origin.

The proportion of occupational dermatoses to all diseases met with among workers is also very variable. Thus, Emmons gives a percentage of 2.4, based on 963 observations; Lane gives 6.8, basing his statistics on 71,575 cases observed in factory dispensaries, but the percentage fell to 3.8 when burns and wear-and-tear of the fingers were eliminated.

In the State of Ohio, 3,241 cases of occupational diseases notified during five years, from 1 July 1920 to 30 June 1925, included 2,632 cases of dermatoses. Recent figures dealing with 4,870 cases of sickness observed during three years in the clinic of industrial diseases of the hospital of Massachusetts included 592 cases of dermatoses, 147 of which were of occupational origin, according to Parmentier and S. Dubreuilh.

The relative incidence of the different forms of occupational dermatosis exhibits the following data according to Oppenheim among 1,061 cases collected in 1910 and 1915: eczemas and dermatoses, 341; burns and injuries by caustic substances, 483; rhagades, 51; excessive sweating, 30; impetigo, 126; chilblains, 12; herpes tonsurans, erysipeloid, 4; pimplies from oil, tar lesions, 10; poisoning of the skin by toxic substances, 2.

Numerous statistics have been collected in separate occupations, but references must here be restricted to only a few of them.

In Germany the number of cases of occupational dermatoses per 100 workers in a large chemical works between 1881 and 1904 has been classified by Leymann as follows:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Cases per 100 Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seamless Tube Workers</td>
<td>11.2</td>
</tr>
<tr>
<td>Plasterers</td>
<td>11.9</td>
</tr>
<tr>
<td>Chemists</td>
<td>12.0</td>
</tr>
</tbody>
</table>

In another statistical table relating to the whole of this industry in Germany during the period 1900-1910 the cases of occupational dermatoses per 100 workers are classified as follows:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Cases per 100 Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>All manual workers</td>
<td>8.10</td>
</tr>
<tr>
<td>Workers on sulphur, nitric and hydrochloric acids</td>
<td>11.06</td>
</tr>
<tr>
<td>Workers on crude and crystallised soda, caustic soda and salts of soda</td>
<td>26.40</td>
</tr>
<tr>
<td>Workers on caustic lime and chloride of lime (for the period 1891-1904 only)</td>
<td>8.10</td>
</tr>
<tr>
<td>Workers on regeneration of sulphur, sulphates</td>
<td>13.73</td>
</tr>
</tbody>
</table>

In Ontario, Canada, for the period from January 1921 to July 1925 there were reported 73 cases of dermatoses, out of 472 cases of occupational diseases; of
these 55 were caused by nickel, 15 by sugar and 5 by chromium. Only 21 cases of nickel dermatosis were compensated out of 173 cases compensated for occupational diseases.

Guy Lane was able to draw up the following occupational classification for grouping 1,342 cases out of 2,000 cases of occupational dermatoses:

<table>
<thead>
<tr>
<th>Occupations</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housewives</td>
<td>702</td>
</tr>
<tr>
<td>Labourers and factory workers</td>
<td>175</td>
</tr>
<tr>
<td>Painters</td>
<td>87</td>
</tr>
<tr>
<td>Metal workers</td>
<td>73</td>
</tr>
<tr>
<td>Workers in the oil and fat industries</td>
<td>67</td>
</tr>
<tr>
<td>Sanitary employment</td>
<td>57</td>
</tr>
<tr>
<td>Sellers of fabrics, and tailors</td>
<td>49</td>
</tr>
<tr>
<td>Bakers</td>
<td>48</td>
</tr>
<tr>
<td>Tanners and workers on skins</td>
<td>40</td>
</tr>
<tr>
<td>Makers of chemical products and medicaments</td>
<td>40</td>
</tr>
</tbody>
</table>

An investigation made in the State of New York for 1928 into 390 cases of dermatitis of occupational origin showed that 24.2 per cent. were incapacitated from work for twelve months, with one or several relapses in the year; 21.5 per cent. for one to three months; 16.4 per cent. for four to six months; 14.9 for two weeks to a month. The cutaneous lesions were as a rule situated on the arms and hands (91), lower extremities (30). In 118 cases charwomen were affected.

Cases of dermatitis reported by voluntary notification to the British Medical Inspectorate of Factories are numerous and interesting: 305 in 1924; 336 in 1925; 429 in 1926; 525 in 1927; 662 in 1928; 834 in 1929; 789 in 1930. In 1928, Bridge reported that 16.5 per cent. of the male cases and 8.8 per cent. of the female cases had had one or several attacks of dermatitis, and that the greatest number of these cases occurred in persons aged from twenty to thirty years.

In 1934 Bridge published the following table:

### DERMATITIS: PRINCIPAL OCCUPATIONS

<table>
<thead>
<tr>
<th>Occupations</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>1932</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyers and calico printers</td>
<td>50</td>
<td>54</td>
<td>104</td>
<td>82</td>
<td>104</td>
</tr>
<tr>
<td>Engineers</td>
<td>108</td>
<td>114</td>
<td>102</td>
<td>90</td>
<td>125</td>
</tr>
<tr>
<td>Labourers</td>
<td>51</td>
<td>53</td>
<td>74</td>
<td>56</td>
<td>57</td>
</tr>
<tr>
<td>Metal platers and polishers</td>
<td>44</td>
<td>53</td>
<td>66</td>
<td>44</td>
<td>94</td>
</tr>
<tr>
<td>Bakers</td>
<td>53</td>
<td>50</td>
<td>58</td>
<td>59</td>
<td>92</td>
</tr>
<tr>
<td>Leather workers and tanners</td>
<td>45</td>
<td>40</td>
<td>50</td>
<td>49</td>
<td>53</td>
</tr>
<tr>
<td>Chemical workers</td>
<td>30</td>
<td>35</td>
<td>31</td>
<td>35</td>
<td>46</td>
</tr>
<tr>
<td>Sanitary employment</td>
<td>20</td>
<td>19</td>
<td>31</td>
<td>25</td>
<td>55</td>
</tr>
<tr>
<td>Sugar confectioners</td>
<td>26</td>
<td>27</td>
<td>30</td>
<td>30</td>
<td>38</td>
</tr>
<tr>
<td>Metal workers</td>
<td>25</td>
<td>27</td>
<td>28</td>
<td>21</td>
<td>31</td>
</tr>
<tr>
<td>Textile workers</td>
<td>18</td>
<td>20</td>
<td>20</td>
<td>55</td>
<td>29</td>
</tr>
<tr>
<td>Oil refiners</td>
<td>6</td>
<td>7</td>
<td>19</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Printers</td>
<td>15</td>
<td>12</td>
<td>18</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Sugar refiners</td>
<td>15</td>
<td>9</td>
<td>13</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>Pottery workers</td>
<td>15</td>
<td>12</td>
<td>9</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Flour workers</td>
<td>15</td>
<td>12</td>
<td>9</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Biscuit makers</td>
<td>15</td>
<td>12</td>
<td>8</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Total cases receiving compensation under Workmen's Compensation Act</td>
<td>1,367</td>
<td>1,685</td>
<td>1,902</td>
<td>1,679</td>
<td>1,940</td>
</tr>
</tbody>
</table>


Cases of dermatoses compensated under the British Workmen's Compensation Act (restricted to cases reported among factory workers, who, as a matter of fact, account for almost all the cases of dermatoses) give the following data: 1920: 391 cases out of a total of 869 factory compensation cases for all causes; 1921-1922: 215 out of 953; 1923-1924: 807 out of 1,834; 1925: 377 out of 1,119; 1926: 685 out of 1,106; 1927: 879 out of 1,394; 1928: 1,146 out of 1,571; 1929: 1,399 out of 1,942. An annual average of 966.6 out of 1,365.8; that is, over 50 per cent. of all the cases of occupational disease for the years 1930, 1931 and 1932, data are as follows: 1,445 out of 2,066; 1,229 out of 1,687; 1,484 out of 1,952.

In Switzerland, the National Accident Insurance Fund compensated, during the period 1922-1927, 702 cases of dermatoses from a single cause and 56 cases of dermatoses due to several causes of injury; it has, in addition, compensated 4 cases of permanent invalidity from dermatosis. The most common causes of injuries of the skin were: (including sulphuric, nitric and acetic), petrol, lime, the chromates, the nitro- and amido-derivatives of benzine, chloride and chloroform, tar and pitch, and chloride of tin.

### GENERAL SYMPTOMATOLOGY

The period included between the commencement of the action of the In-
juristic cause and the development of the dermatoses varies according to the nature of the agent and the personal reaction. Dust or fumes generally act less rapidly than liquids and solids which are not pulverised. Microbes always abound in the parts of the skin exposed during work to contact with the products, which accumulate, in preference, on the salient parts, articular folds, wrinkles, the hairs of the body, up to the edge of the scalp, at the palpebral borders, the auditory meatus, and at the nares. However, the lesions are quite often situated on covered parts, especially at certain points, for example the region of the belt, the inguinal folds, the genital organs in man and the site of the garters in women. For reasons not so far understood, certain regions are affected to the exclusion of others equally exposed: thus, on the hands, lesions may be seen limited to the palm, or, on the contrary, to the back of the hand, stopping abruptly, in this latter case, where the direction of the special epidermic folds indicate the commencement of the palmar surface.

Moreover, the cutaneous conditions may spread over a more or less extensive part of the skin, or become generalised over the whole surface of the body.

The clinical forms of occupational dermatoses vary according to the nature of the injurious agent, the duration of the lesion and the constitution of the individual.

The first stage is represented by vascular disorders, which are the consequence of an alteration in the nutritional elements of the skin; these react by a defensive process, if the irritation is not too acute; if the contrary is the case, they succumb.

Microbes, which always abound in the superficial parts of the epidermis, especially in persons who are not too particular, penetrate into the deep layers through the chafings which furrow the skin, and multiply in the exudates which were originally aseptic, thus transforming the dermatitis into a pus infection of the skin. The lesion may then extend by continuity and even by being transferred to a distant site, whence arise special lesions of the face and, in man, of the genital organs.

The vascular disorders consist chiefly of an erythema, often accompanied by oedema of the skin. On this erythematous base, vesicles next develop, the contents of which discharge and become dry, so giving rise to the formation of crusts. The vesicular type may take on an eczematous character; by secondary infection, the vesicles become transformed into pustules, when their confluence may originate lesions of many different forms.

It would seem reasonable to classify the extremely numerous clinical forms according to their etiology and origin; most of the cases this is difficult to specify. Further, the various ways in which the skin reacts are common to numerous irritants.

References should be made to the sections below dealing with "occupational stigmata," effects of heat and cold, including burns and chemical burns, and "nails and hair"; also to the articles on "Electricity," "Radium and Radioactive Substances," "Tumours of Occupational Origin," and "Infectious Diseases" for the dermatoses arising from the causes in question.

Affections of the sudoriparous glands and the sebaceous glands are due to such substances as resins, dust and oils, which penetrate into them and obstruct their orifices, leading to the formation of comedones and folliculitis. There are many recorded cases of oil pustule (eliaoconiosis) which affects workers in metal industries (see article "Petroleum"); acneiform folliculitis, met with among workers handling tar and its derivatives, lamp black, asphalt and pitch, among workers at petroleum refineries and paraffin works, and also among cement workers; toxic acnes, of which the best known are chlorine acne and bromine acne; follicular keratosis, seen among workers using a mixture of zinc oxide, emery and pumice stone.

Some substances, such as aniline and chloride of lime act on the sudoriparous glands, leading to hyperhydrosis, which, in its turn, favours the development of dermatocnosis; in other cases, the effect produced is an anhydrosis with toxic dermatitis.

Sweat may show a coloration varying with the material employed; such as green, in brass and copper workers; and blue, among those who handle methylene blue. It may also have an odour which varies according to the substance which causes it; as, for example, an odour of violets after the inhalation of turpentine vapours.

When eruptions are produced, in which the principal part is played by the integuments becoming sensitive to irritant agents, on the one hand, and, on the other, by the production of a hemoglobin shock breaking up the blood, which, however, is not constant, they may assume very different aspects: redness slightly marked with spots; erythema-morbilliform, diffuse or scarlatiniform; urticaria; lichen; oedema
without erythema; erysipeloid eruptions; vesicles or bullae. They may be generalised, or, as is more usual, localised; their development is generally acute.

Cases of dermatitis, due to the irritant action of a foreign substance, vary clinically with the nature of the irritation. Their intensity depends especially on the lesions of the epidermis, and the starting-point of the cutaneous affection.

Eczemas are very important on account of their frequency and the influence they exert on the economy of labour owing to incapacity for work.

Almost all authorities actually regard eczema as a disease caused by sensitisation. Oppenheim, however, distinguishes between skin poisonings or artificial dermatites and occupational eczemas properly so called. These last only appear on integuments which have become sensitive; they persist after, and in spite of, the disappearance of the injurious agent, thus differing from cases of dermatitis in which the cutaneous reactions are due to the activity of some irritant cause and disappear with it.

Jadassohn regards eczemas as poisonings of the skin due to cutaneous reactions against non-microbial irritants which are clinically and histologically quite clearly defined.

Predisposition may be congenital, i.e. an "idiosyncrasy", or acquired, i.e. a "sensitisation". A predisposition is necessary; but very little is known about the condition of sensitisation.

The theories advanced to explain the pathogenesis are still more numerous: on the one hand, an antigen, which is represented by numerous external substances or produced within the body, is suggested; and, on the other hand, a sensitisation resulting from hereditary or acquired changes in the body (Ravaut). Eczema may be regarded as resulting from an abnormal cutaneous sensitisation to certain agents, which may be a congenital idiosyncrasy or an acquired allergy; or eczema may be considered as a cutaneous affection due to an alteration in the sympathetic vaso-motor system (Millan).

Occupational eczema does not occur so much under the influence of the sensitisation to a definite substance as under the action of repeated and prolonged exposure to all the collection of causes of skin irritation which may arise during work. True occupational eczema should be considered as the result of physical or chemical changes in the corneal layer and of the epidermal fat, rather than as a pure allergic process. Oppenheim considers that water plays a very important part, because, after maceration of the corneal layer, it leads, by mechanical action, to fissuring of the superficial layers of the epidermis.

The symptomatology of occupational eczemas is similar to that of natural eczemas. The damage occurs chiefly on the uncovered parts. The right hand is more often affected than the left, and the dorsal surface more often than the palmar. The development is acute or chronic, with exacerbations, and sometimes it is complicated by a mixed infection. Cessation from the occupation generally leads to a cure, whilst the return to work may produce either a relapse or a second attack from causes which are often ill defined.

It is difficult to separate clearly the groups which have been discussed, for their symptomatology has many points in common. Each irritant product may, in different individuals, lead to manifestations characteristic of one of the groups, while developing towards conditions peculiar to other groups.

Substances of vegetable or animal origin, either in their natural or

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1 It is proposed here to cite merely certain cases of skin affections observed as the result of handling plants belonging to the most varied species:

Buxus sempervirens: erysipeloid dermatitis in a gardener (Oppenheim).

Solidago virga aurea: maculo-papular dermatitis accompanied by itching and burning, in four peasants after three to twelve hours work at hay making (Sutton).

Chrysanthemum leucanthemum: inflammation of the face in a flower seller; the hands were not affected; cessation of work caused the condition to improve (Dawson).

Chrysanthemum indicum: a skin irritation of the face and hands, accompanied by fever, in a gardener (Hoffer).

Pyrethrum: dermatitis in gardeners and workers employed in crushing and packing. McCord distinguishes four forms: (1) vesicular dermatitis, the most frequent; (2) poisonous erythema (50 per cent. of cases); (3) popular dermatitis; (4) anaphylactic form (in an engineer at an insecticide powder factory).

Doronicum pardalianches: diffuse redness of the face, hands and feet in a woman employed on gathering these roots (Hoffer).

Helianthus annuus: dermatitis, observed by Dreger.

Equisetum tinosorum: exanthem on the forearms and neck of a woman who had cleaned metal objects with a decoction of equisetum, soda and animal bile (Kulp).

Graminaceous plants: popular exanthem with itching, often accompanied by fever, which lasts between six and twelve hours. Hoffer mentions several graminaceous plants which have caused epidemic dermatitis. Twenty-five members of seven families were affected with erythema after having cut Sorghum (Hoffer).

Exanthem resembling strophulus observed by Hodara in porters carrying rice sacks at Constantinople, by Loir and Légaugneur at Havre.
changed state, may cause cases of dermatitis (see articles "Poisonous Woods", "Cantharides", "Gardeners and Market Vegetable Workers", "Silk", "Sugar Refining", etc.).

Interest may here attach to mentioning, even though briefly, the morbidity anaphylactic syndrome characterised by different phenomena: superficial lesions of the mucous membranes, asthma, circulatory and respiratory disorders. The anaphylactic agent, whether of animal, vegetable or chemical origin—the antigen—has its effect explained by its action on some special soil, particularly prepared as the result of heredity, or reasons of diathesis and constitution, based on morphology, neuroses or disorders of the endocrine apparatus; this soil presents a predisposing state which is necessarily latent.

Melanosis, hyperkeratoses and atrophies are partly occupational stigmata or manifestations accompanying cases of dermatitis, folliculitis and the diseases properly so called. Melanosis,

by Alderson and Rawlins among dirty workers employed on rice (see article "Rice").

Quercrocho Schinopsis Lorentzii: a cause of dermatitis in the hands reported in the province of Santiago and due to contact with leaves, branches and sawdust. The symptoms reported by O. di Lulio (1926) were itching, oedema and a skin eruption.

Mucuna pruriens: a cause of dermatitis among workers on sugar-cane fields.

Phaseolus vulgaris: recurrent erythema in predisposed workers, due to contact with french beans in preserving factories (Sternthal). The factory inspection department at Brunswick has prohibited this kind of work for susceptible persons.

Asparagus: diffuse redness accompanied by swelling and military vesicles on the arms and hands of a woman employed in cleaning asparagus. A niece of the patient showed the same redness and swelling.

Hyaecithus: skin irritation on the sides of the fingers, occurring every year during work on bulbs (Broers). See also article "Gardeners".

Linnun ustutattismum: varioloïd exanthem in a young girl employed in a Russian flax mill for the lubricating oil (Purdue); among the spinners and bobbin boys (Leleij). Flax-workers' fever (Heijermans); attacks of asthma in flax grovers (Voskamp).

Cannabis indica: inflammatory dermatitis in a rope maker who sorted Indian hemp (Rorlas).

Humulus Lupulus: Skin affections accompanied by redness, fever and oedema in a young girl, twenty-four hours after a stay in a hop yard (O'Donovan). An exanthem on the face, hands and feet in a weaver of hemp for about forty years, after six days' work with hops (Streich).

Fumaria planifolia: redness and swelling of the hands, forearms and neck of a young woman, twenty-four hours after a stay in a hop yard (O'Donovan). An exanthem on the face, hands and feet in a weaver of hemp for about forty years, after six days' work with hops (Streich).

Vanilla planifolia: redness and swelling of the hands, forearms and neck of a young woman, twenty-four hours after a stay in a hop yard (O'Donovan). An exanthem on the face, hands and feet in a weaver of hemp for about forty years, after six days' work with hops (Streich).

which has been especially recognised since the war through work on experimental cancer in mice, appears as a pigmentational reaction which is due either to the direct pigmentary action of the material absorbed, or to the action of light-sensitive substances. It is chiefly met with among workers in tar, asphalt lubricating oils, arsenic and vaseline. Diffuse or circumscribed follicular hyperkeratoses accompany the folliculitis of hyperpigmentation and dermatitis in persons doing work where such derivatives of carbon as pitch or petroleum, vaseline or petrol, are used. They are also met with in butchers, pork-butchers, tanners, depilators of pig skins and washers of cobalt ore.

Atrorhizus spinosus and Atrorhiza grandiflora: dermatitis in gardeners employed on amelopsia quinquetoila (Harrison). Cases may also be mentioned of dermatitis from celery (Lortat-Jacob and Legrain), from tomatoes (Foä), from the juice and essence of lemon (Lorriga) and of orange, from Avundo donaz and of turpentine (Lorriga). These cases, due to a fungus. See also article "Perfumes".

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on to a previous skin lesion, or primary from the first. (See articles "Foot and Mouth Disease", "Glanders", "Syphilis (Occupational)", and especially the article on "Infectious Diseases". As regards skin lesions due to the action of various parasites, see article "Parasites").

**Prognosis**

In most of the cases it is not difficult to predict the development and the duration of occupational dermatoses.

Removal from the irritant cause, followed by adequate treatment, often leads to the cure of cases of industrial dermatitis and exogenic eczemas, provided that these lesions are not complicated by secondary affections or constitutional predispositions, which may greatly retard the recovery.

Prognosis, then, depends on the possibility of removing the patients; but, unfortunately, such a measure is not always understood; and very often patients are to be seen employed on work which is not suitable for them.

Another feature in prognosis rests on the individual constitution, from the point of view of resistance, either general, or of the skin. The most tenacious forms are the eczematous. The rapidity of the cure of ulcers or suppurations due to the action of irritants depends on the depth and the extent of the lesions. Some large rebellious ulcerations may leave behind chronic weaknesses, or become complicated by such secondary affections as panaritis, phlegmons, leading to vicious cicatrices, with retraction of the palmar aponeurosis, followed by pitting of the skin (pigeonneaux). Some products, such as derivatives of oils, tar or chlorine, may cause lesions with a tendency to malignity. In the early stages, the process is invariably local. Immediate extirpation, or immediate cessation from work, gives satisfactory results, and the neoplasm does not recur. New tumours may, however, develop years after exposure to the toxic product has ceased; and that is a point which must not be forgotten. On the other hand, some cicatrices may, after a certain time, become cancerous (Prosser White).

**Prophylaxis**

Prophylaxis depends on an exact knowledge of the occupational risks, on the efficacy of protective measures, on precise and minute attention to these measures, and upon the cooperation of everyone towards improving existing conditions.

There is a natural prophylaxis, for many of the workers become accustomed to resist the causes of the changes; they acquire a kind of adaptation of the skin to external irritation.

In addition to general hygienic measures in workshops, including ventilation, removal of fumes, gases, vapours, the use of closed apparatus, arrangements for preventing splashing and direct handling of certain products, there is a series of important personal measures: selection of personnel by medical examination on commencing work, with the exclusion of certain persons; periodical examination in order to eliminate from some kinds of work predisposed individuals or those already affected; the detection of injurious products — which is often very difficult; cleanliness of the skin; thorough drying and greasing of the hands and skin exposed to injurious products; with non-irritant substances at night and, if possible, during work; first aid even in the case of the smallest lesions; periodical examination of the hands and forearms; and the use of gloves.

The instruction and education of the personnel must be assured by bringing to their knowledge the dangers they run, and the measures of protection, by means of leaflets, posters and lectures. There are various types of poster, among which should be mentioned that issued by the British Medical Inspectorate of Factories: Form 307, April 1928: "Dermatitis Cautionary Notice"; that of 1929 on dermatitis in peelers of oranges and lemons; the regulations of the Industrial Association of the German Chemical Industry. Any measure, however detailed and strict, may be inefficacious if the persons who are exposed are not first convinced of the necessity for self-protection (Fischer).

**Legislation**

The general hygienic measures vary according to the etiological agents (see the articles devoted to various industries and occupations) and are contained in the texts of the Laws, Decrees, Regulations, and Orders made by responsible authorities.

In some countries as a result of compulsory medical examination before commencing work, persons affected with dermatoses are excluded by law (Japan), and also at periodical examinations.

Compulsory notification of dermatoses is provided for in the mandated territory of South West Africa, e.g., dermatitis by cyanide; in Germany and in France, dermatitis caused by chromic acid, by caustic products and lime, formaldehyde,
mineral oils, and epitheliomatous cancer of the skin; in Great Britain, epitheliomatous cancer of the skin and ulcerations due to chromium; in Missouri, dermatitis caused by mineral acids, acetic acid, alkalis, chlorine, and its derivatives, fluorine and its derivatives, the derivatives of copper, tar, and other corrosive or irritating substances used in industry, dermatitis of the fingers caused by handling silk, eczema of grinders, or dermatitis affecting workmen using tar, and the lesions due to cement and to the derivatives of hydrocyanic acid; in Queensland, for miners' itch, the itch from copper, dermatitis due to work in acid mineral waters, ulcerations from chromat, dermatitis from toxic woods, mineral oils, pitch and tar; in Switzerland, for the skin lesions arising from injurious causes enumerated in a schedule; in the U.S.S.R., for serious affections of the skin, incurable cases of dermatitis, inflammations, malignant tumours and atrophies due to X-rays.

Occupational dermatoses also entitle the worker to compensation in countries which have declared occupational diseases, by definition, to be accidents incurred at work (New South Wales, etc.). The Correspondence Committee on Industrial Hygiene of the International Labour Office studied, at its meeting at Düsseldorf in 1925, the question of the affections requiring to be added to the list of diseases to be compensated, annexed to the Convention voted at the International Labour Conference of 1925. Among these affections it retained also recurring dermatoses due to the action of dust and liquids, and epithelioma of the skin from handling tar, pitch, bitumen, mineral oils, paraffin and any compounds, products or derivatives of these substances.

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See end of article.

Nails and Hair


The various harmful agents which injure the skin are not without their effect on the nails and hair. As regards the former, the trouble is usually located on the skin which surrounds the nail (rhagades, eczemas, warts, forms of lymphangitis, etc.), either the matrix of the nail (modification of the quality of the new nail, deformation, cleaving, superposition of both halves of the matrix, heterotopy), or the root of the nail with affection of the nail properly so called (haemorrhage, sup-

As regards legislation concerning dermatitis from arsenic, chromium, chromat, cancer of the skin and ulcerations from tar, pitch, paraffin, soot, oils and X-rays, see the corresponding articles.
puration, dermatoses, hyperkeratosis, hyperidrosis, onycholysis, circulatory derangements, etc.). The nail properly so called may be eroded by physical or chemical agents, impregnated with colouring matters or attacked by moulds. The diseases of the ungual phalanx (hypertrophy; acromegaly; atrophy; sclerodactyilia), or general troubles (tuberculosis, syphilis, leprosy, gangrene, diabetes, arteriosclerosis, stasis of the blood, heart troubles, phthisis) all exert important effects on the health of the nails. On the other hand, any injury to a part of the nail has an effect on the entire organ (“ungual altruism”: Heller). Finally, general affections may lead to nail trouble. Thus, for example, a mason suffering from warty tuberculosis of the skin round the nails, a worker may suffer from nickel action or the phthisis may present hippocratic deformity (Beau); from rheumatism may show striae of the nail, etc. Thus, for example, a mason suffering from rheumatism may show striae of the nail, whilst a nickel worker may suffer from nickel itch capable of spreading to the nails, and a butcher who is a carrier of bovine tubercular bacilli on the hands may suffer from warty tuberculosis of the skin round the nails, etc.

The absence of all statistical data relating to occupational affections of the nails renders it impossible to convey an idea of the frequency of the occurrence of such troubles. It may, however, be concluded that skin diseases from which workers suffer are often accompanied by injury to the nails, and in this way it is possible to determine a certain proportion of incidence of such troubles.

First of all there are nail troubles which are not diseases properly so called but only alterations of physical character which do not cause deep-seated injury to the structure of the nail: deposits of dust (carbonates, powdered glass, vegetable dusts), animal debris, fatty substances, colouring agents (indigo, picric acid, pyrogallic acid), erosions (workers in the dyeing industry), polishing (pottery workers), loss of substance and pricks (dressmakers), rubbing away of the nails (packers), etc. On the other hand, diseases of the nails properly so called have been described, the outbreak of which is dependent on the individual constitution. Heller enumerates the following:

Onychomycosis of brewers due to hyphomycete and brewers’ mould. The latter usually attacks workers engaged in cleaning the fermentation vats; the nails present longitudinal fissure with facets and crusty excrescences at the root.

Ungual erosion of workers manipulating chloride of lime.

Ungual diseases of dye workers: the nails become thin, bluish in colour, deformed, and finally fall off (Gotthilf); warty proliferation, subungual hyperkeratosis (dyers and furriers, Leviseur); inflammation and suppuration (aniline dyes: Naegelin); ungual infection of furriers (Gilbert).

There is further alteration due to imbibing amongst workers handling formaldehyde (formalonychia: Galewsky); brown coloration, softening, periungual alteration and pigmentation (dark blue) amongst electro-platers, disarrangement of growth of the nails, atrophy and suppuration amongst workers engaged on cleaning vegetables, resorption and difficult regeneration of the nails amongst glassworkers (one case observed by Oppenheim) due to the use of caustic soda; forms of ungual inflammation amongst hatters are due to the combined mechanical action of the hair and of the substances employed (lime, sulphuric acid), transversal striaion and falling of the root of the nail amongst miners, poisoning by carbon monoxide (disaster at Courières: Lewin), hyperaesthesia in patches; these troubles were attributed to nephritis brought about by the poisoning; paronychia of confectioners due to burning sugar and affecting predisposed individuals; clinically, this affection takes the form of an acute ungual eczema.

In America in 1925 there was described a form of contagious paronychia amongst workers in jam factories. Bacteriological examination and experiment resulted in attributing the affection to the leaven used (Kingery and Thines).

Paronychia also occurred amongst peelers and squeezers of oranges (Sutherland-Campbell, 1929), and of lemons (Loriga, 1928).

Alteration of the nails occurs amongst painters — case of Thieberge and Weissenbach affecting a painter suffering from lead poisoning; there was said to be connection between the ungual trouble and the general poisoning; clinically, there is thickening and appearance of white spots on the nails; lancinating pains and falling of the nails without normal regeneration. Friability of the nails occurs amongst workers handling mercury (local action).

Cases of ungual trouble have been reported during mercurial poisoning (one case: Hirschfeld; two doubtful cases: Küssmaul).

Radiologists suffer from thinness and friability of the nails, and workers engaged in pleating straw from infection
of the nails by hyphomycete (one case: Dereuw).

Wearing of the nails with dorsal thickening of the ungual phalanx (combined mechanical and chemical action) occurs amongst workers engaged in rolling cigarettes.

Wearing of the exterior part of the matrix of the nail of the left little finger, especially on the radial side near the top of the finger, as well as recoiling and atrophy of the matrix of the nail of the right thumb has been noted amongst pianists.

Deforming scars and formation of fissures have been noted as a consequence of combustion and burning, and transversal striae and eczematous alteration of the nails due to exposure to cold and frost. Partial semi-lunar onycholysis has been noted amongst washerwomen (15 cases: Erismann), and diseases located on the nails and ends of the fingers amongst workers in the woollen industry. In the cellulosic industry the English medical inspectors (1927) and Casazza (1928) in Italy have noted special injuries to the nails which, according to Casazza, have a highly polished bright red appearance resembling the enamelled nails of fashionable women. The nail is flattened, thin, and presents fairly deep fissures; its edge is loosened and tends to turn. In Russian leather factories, Kiebenoff and Embdin (1927) have also noted modifications of the free border of the nails, as well as lesions of the skin surrounding the nail.

Injury to the hair consists in falling due to certain causes (light, heat, toxic products, various forms of dermatitis), or hypertrichosis or hyperpigmentation (porters who carry burdens on their head and shoulders) or, finally, varied coloration due, for instance, to copper (smelting, various products, munitions), to arsenic, chlorine, picric acid, etc.

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**Occupational Stigmata**


Pathological modifications of the skin which are typical of certain occupations, without exactly constituting a state of disease and without interfering with the functional aptitude of those affected, are described and designated by the term "occupational stigma". In certain cases involving callosities the work is even facilitated and gains in precision. Apart from that, certain organs (cartilages, bones, muscles and joints), as well as the skin, undergo typical modifications. The epidermis and the subcutaneous cellular tissues participate in this change, which frequently implies a reaction to various forms of irritation, either mechanical, chemical or physical, and it is in fact frequent recurrence of chronic irritation which brings about such changes. Pigmentation or deposits are, on the other hand, rather of an external and mechanical nature, and in no wise modify the skin or its functions.

The combination of external irritants, particularly those of a chemical or mechanical nature, engender stigmata which may appear after a few weeks, a few months or, more rarely, a few years. It is certain experts who are inclined to classify stigmata under the group of occupational changes of a transitory nature.

The production and symptomatology of occupational stigmata have engaged the attention of numerous recent authors, amongst whom may be quoted Blaschko, M. Oppenheim, Teleky and Koechs as regards those affecting the teeth, Heller those affecting the nails, and B. Chajes and Natori (Japan) as regards the formation of callosities, etc.

It is not always possible to distinguish between occupational stigmata and forms of dermatosis. The majority of workers engaged in a trade develop such stigmata, those remaining immune forming an exception due to absence of predisposition. On the other hand, the production of dermatoses occurs sporadically, being strictly connected with individual and constitutional factors.

Stigmata are of practical importance from the point of view of industrial medicine, both as regards diagnosis and as regards their medico-legal aspect for purposes of compensation.

From the anatomo-clinical aspect, occupational stigmata may be grouped according to type and according to duration.

Oppenheim mentions among permanent changes: pigmentation, corni-

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1 Oppenheim has utilised since 1916 in the study, preparation and determination of occupational skin changes particularly those assuming the form of callosities, atrophies and cicatricial formations, etc., a procedure anal-
ication, callosities, telangiectasis, tattooing, and cuticular formations. Amongst the transitory changes he includes pigmentation, deposits, rhagades and excoriations of the skin with typical localisation, as well as changes in the nails, teeth and mucous membranes. Almost invariably the injurious occupational agent exerts its action directly on the skin, and more frequently indirectly (circulatory passages), producing in this instance melanoderma argyrosis of the entire cutaneous surface or of certain more or less extensive areas thereof.

Individual predisposition is essential for the pigment formation in occupational stigmata. Pigmentation of the skin does not present extensive biological modifications of the deep-seated regions of the skin. It may affect the hair, the nails, the mucous membranes and the teeth. The majority of the clinical pigments usually disappear as a result of physiological desquamation of the epidermis.

Certain forms of pigmentation are the result of chemical modification of the cellular elements produced by certain substances: yellow, reddish brown coloration (nitric acid); brown (black sulphuric acid); brown (chrome); greenish yellow on the skin and olive green on the hair (picric acid: melanitits (Matussewitsch); yellow-green or apricot (tetryl); yellow or brown (dinitrobenzene and trinitrotoluene, more especially impure products); locking coal have been described by Fabry-Dalton, which transfers to the skin by means of special localisation of the mechanical pressure and friction chiefly and also ichthyosis and hyperidrosis play an etiological role. Ichthyosis sets up on the buttocks through sitting on hard seats, callosities taking the form of ridges on the folds of the finger joints (drawing of the thread); tailors: palm surface and fingers (hot pressing), front of the thumb (from holding the scissors), terminal phalanx of left first finger (from pressure of the needle and pricking); locksmiths: right palm surface (use of the hammer and file); bakers: palmar and cubital surface of the little finger (pressure on the kneading board); file cutters: same localisation, limited, hard pressure of the thumb; region (Teleky); farriers: fourth and fifth fingers of the right hand and tip of the little finger; hatters: internal palmar region (from pressure on the board), first phalanx of the third finger (annular callosities caused by the strings); cloth printers: cubital region of the hypothenar eminence of the little finger; workers engaged in carrying weights: region of the shoulder (pressure of the boxes or cases); painters and varnishers: second phalanx of the second and third right hand fingers (painter's brush), palm and index fingers of the right hand (pressure on the palette); clerks: terminal phalanx of the middle finger; workers engaged in manipulating morocco leather: index finger of the right hand (putting of the leather); saddlers: region of the wrist joint of the right hand (pressure of the thread), extensive callosities on the

alabaster, bronze (Carozzi), glue (Chajes), lime mortar, cement, varnish, colours (workers in the building trade, painters), animal substances and hair (furriers, hatmakers, stable boys, brush manufacturers), etc. Various forms of deposits found amongst workers handling coal have been described by Fabry-Beckolt and K. Pichler.

In the production of callosities and pathological cornification mechanical pressure and friction chiefly and also ichthyosis and hyperidrosis play an etiological role. Ichthyosis sets up hard dark callosities whilst hyperidrosis gives rise rather to soft translucent alterations of a clear yellow tinge. Very hard pressure may in certain instances cause extensive callosities and in certain cases blistering and atrophy.

Certain occupations are characterised by special localisation of the mechanical action exerted giving rise to typical callosities at the site in question: joiners: thumb and fold of the first finger of the right hand; middle of the palmar surface (pressure of the plane); shoemakers: fold at finger joints (pressure of the handle of the hammer), thigh, towards the kneecap (pressure whilst manipulating the leather), callosities on the buttocks through sitting on hard seats, callosities taking the form of ridges on the folds of the finger joints (drawing of the thread); tailors: palm surface and fingers (hot pressing), front of the thumb (from holding the scissors), terminal phalanx of left first finger (from pressure of the needle and pricking); locksmiths: right palm surface (use of the hammer and file); bakers: palmar and cubital surface of the little finger (pressure on the kneading board); file cutters: same localisation, limited, hard pressure of the thumb; region (Teleky); farriers: fourth and fifth fingers of the right hand and tip of the little finger; hatters: internal palmar region (from pressure on the board), first phalanx of the third finger (annular callosities caused by the strings); cloth printers: cubital region of the hypothenar eminence of the little finger; workers engaged in carrying weights: region of the shoulder (pressure of the boxes or cases); painters and varnishers: second phalanx of the second and third right hand fingers (painter's brush), palm and index fingers of the right hand (pressure on the palette); clerks: terminal phalanx of the middle finger; workers engaged in manipulating morocco leather: index finger of the right hand (putting of the leather); saddlers: region of the wrist joint of the right hand (pressure of the thread), extensive callosities on the
left hand (from pressure of the needle); makers of trimmings and embroideries: callosities on the dorsal region of the fingers; glove makers: similar alterations (resin?); stonecutters: palmar region of the first phalanx of the little finger of the left hand (chisel); printers and compositors: terminal phalanx and tips of the fingers (pressure of the type); house painters: palmar surface (pressure of the brush); engravers: palmar region of the little finger (engraving tools); cigarette makers: six types of stigmata on various fingers due to the effect of the special knife used and to friction of the fingers against the table (Pineiro), etc. (See also alphabetical list of callosities classified under the various occupations prepared by B. Chajes.)

The combination of mechanical and chemical effects favours the outbreak of callosities on the palmar region in pork butchers (Matzenauer), cloth makers and tailors, etc. The combination of thermic action (boiling water and steam) and of colouring agents, etc., used in the manufacture of military blankets causes linear callosities on the palmar surface of the hand more pronounced on the left than on the right hand (Oppenheim), dark pigmentation ranging to brownish black is caused by pressure of the coloured wool against the revolving drum which is covered with very fine steel pins. Diffused callosities of the skin are often met with in cooks. Acrobats and gymnastic teachers suffer from callosities on the palmar surface of the hand and on the legs, and soldiers on the thighs and calves of the legs.

Natori in Japan has made an exhaustive study of callosities (300 cases) connected with various types of work, not only from the point of view of the date of their first appearance and its relation to the duration of working experience of the worker but also to the date of disappearance of the callosities subsequent to removal from the occupation. These researches are chiefly devoted to workers in the silk and thread dyeing industry, and in the textile industry (Nishijin), masons, stonecutters, ironers, photographers and sculptors.

In the various operations in question in Japan the formation of callosities dates from the first or second month, or at least from the period of one year after engagement. Permanent deformation of the fingers does not occur until the worker has been engaged in the industry for a period of three years. The intensity of the work engaged in exercises an effect in this connection.

Prosser-White has made a study of, and described and prepared, pictorial reproductions of forms of cutaneous callosities affecting various workers in British industries.

Other special forms of callosities have been met with in women workers engaged in polishing (nodules caused by leather polishing with emery, situated on the dorsal region of the fingers of both hands after twelve years in the industry: Hess); amongst milkmaids (callosities on the scalp caused by carrying pails on the head: K. Pichler); amongst musicians: J. Flesch, doctor and musician, has published a comprehensive study of these occupational stigmata; in the case of violinists they are located on the left lower jaw, on the tips of the second and fifth fingers of the left hand, on the radial side of the right forefinger, on the inner edge of the right thumb; in the case of double bass players the callosities are situated on the tips of the four fingers of the left hand and especially on the left forefinger and the little finger of the right hand; amongst dancers, on the toes and especially on the inner side of the big toe. Abnormal arching of the foot may be noted in ballet dancers as well as shortening and thickening of the tendons Achilles.

The span of the hand of pianists, violinists and harp players is more extensive than that of other workers; amongst pianists, players of the harp and in the left hand amongst violinists and double bass players there is likewise a characteristic extension of the distal interphalangeal joints. It is with reference to this characteristic stigmata that the Italian double bass player Dragonetti was nicknamed "mano mostro" (monster hand). The callosities are localised on the tips of the thumb and first three fingers of the left hand, and they are more extensive than those of violinists. On the right hand they are located on the dorsal or radial region and often on the tip of the little finger and are due to pressure from the bow. Wind instrument players show small scaly patches as well as a painless annular excrescence on the lower lip. In the case of flute players eczema of the lower lip is occasionally met with and attributed to a special composition of the mouthpiece (resin?). Pianists occasionally suffer from loosening of the edge of the nail of the left little finger and of the right thumb. The nail of the left little finger is frequently atrophied and loosened at the root. The terminal phalanges are short and broadened.

Perspiration of the hands constitutes a source of inconvenience to pianists
and violinists, etc. This condition favours the outbreak of forms of eczema which appears around the folds of the joints of the forefinger. There has also been reported a form of dermatitis due to the action of rosin amongst violinists; keratosis of the lower jaw due to permanent pressure against the chin rest of the instrument (or the varnish of the violin: rosin, anthracene, acridine).

Work in the open air, in the sun and in all weathers, as well as occupations effected in enclosed premises where the workers suffer from exposure to radiant heat from hearths, sets up forms of pigmentation more or less accentuated or at times exclusively confined to the uncovered regions of the skin notably the face and hands: agricultural workers, gamekeepers and trappers, fishers—and violinists; keratosis of the lower jaw also been reported a form of dermatitis of the forefinger.

Pigmentation occurs subsequent to erythema and may be followed by cutaneous atrophy or the formation of warts and epithelioema (peasants, sailors). The effects of heat are responsible for trouble of this kind amongst workers at blast furnaces, foundry workers, those engaged on autogenous welding, blacksmiths, locksmiths and glass workers, etc.

A contrary phenomenon consisting in depigmentation of the teguments has been noted amongst workers in mines and tunnels.

Under the name of argyrosis is designated darkish coloration ranging to black of the skin of the face which recalls the glistening aspect of graphite (Teleky), and may affect the conjunctivae and the cornea (K. Steindorf), as well as the buccal mucous membrane. This argyrosis is caused by the absorption of small quantities of silver solution (nitrate of silver) by way of the mouth, notably amongst workers engaged in making beads by means of the blowpipe.

A local form of argyrosis has been noted amongst workers engaged in the preparation of silver-leaf. The buccal mucous membrane shows a dark brown coloration, whilst the teeth become greyish brown colour (Koeisch).

Arsenical melanosis causing a darkish brown pigmentation of the skin is seen in workers handling arsenical products (miners, foundry workers, electro-platers, etc.). Pigmentation by arsenic is due to increase of the physiological pigment in the deep-seated regions of the epidermis, possibly in consequence of stimulation of the apparatus of the chromatophores of the skin and the suprarenal glands.

Tar likewise causes toxic melanoderma of occupational origin (E. Hoffmann, Habermann) known as "peau de goudron" (tar skin), due to the action of this product under the influence of various sensitising substances. Asphalt fumes have been known to cause reticular coloration of the face, neck and forearms (Dufke and Berndkopf). Buschke has noted that the pigment was only found in the chromatophores and not in the epidermis, whilst H. Fischer found it around the hyperkeratic pores of the sebaceous glands and considered it to be an expression of the elimination of toxic substances absorbed. Workers engaged in the impregnation of railway sleepers with creosote suffer from melanosis of the teguments of the skin of the face and of the body and the same is true of metal turners (Hudelo, Rahut, calliaud, Mornet, Cézary, Pasteur, Valléry-Radot, Benovist) and amongst workers in coal mines (Barnewitz).

Mention should likewise here be made of patches of purpura seen in compressed air workers ("caissons") due to the increase of arterial pressure and to vascular irritation.

Impregnation and tattooing, which Oppenheim classes in a single group, are considered by K. Pichler as due to the penetration into or under the epidermis at the moment of violent contact of foreign bodies with a sharp or cutting edge coming from the materials utilised in the course of work (specially stone, metal, etc.), or of the implements used.

These particles may become chemically modified in the skin, being reabsorbed and transported into the lymphatic circulation, or may remain in position, giving rise to permanent or transitory pigmentation.

They are noted chiefly in workers in metallic mines in the silver and steel industries, etc., and amongst workers manipulating stone and powders; likewise amongst electricians, millers (grinding of mill stones), workers making grindstones (black patches either pointed in appearance or recalling freckles in their dimensions, localised on the back of the hands, the fingers and the fore-arm; permanent globules above the joints especially of the left hand, of a brownish colour due to iron oxides or sulphate); other workers affected are coal miners, chimney-sweeps, manufacturers of margarine and coconut oil (small fragments of the vegetable capsules which may or may not be accompanied by slight inflammation according to the depth of penetration: Chento).
Cooks, blacksmiths, gardeners and coachmen suffer from dilatation and neo-
formation of the cutaneous pre-capillary vessels shown on the face, cheeks and nose and on the hands and back of the fingers by vascular arboration, which disappears on pressure. It is most usually accompanied by hypo-
pigmentation and freckling, which disappears on pressure.

Wounds, often of small dimensions (pricks, scratches, patches), of a form characteristic for certain occupations in certain cases, present an atrophic and exceptionally hypertrophic (chel-
oid) character. Localization varies according to the occupation but is more usually restricted to the uncovered regions of the skin (hands, fore-arms, feet).

In certain cases such wounds are accompanied by pigmentation or other stigmata of impregnation, by deposits, comedones, open sores, inflammation, stigmata of impregnation, by deposits, comedones, open sores, inflammation, etc. Such cicatricial formations at times assume a linear form on the back of the hands and are often accom-
panied by hardened areas and rhagades of recent formation (basket-weavers); in the case of milkmaids such forma-
tions are found in the interdigital folds of the second, third and fourth fingers, being the marks of former suppurating fistulae caused by the hairs of infected cows deposited there during milking (Pichler).

The auricle of dockers and porters often presents formations and callosi-
ties due to pressure and friction (Oka-
jiima).

Mention should further be made of intentional deformations, such as al-
lowing the nails to grow an exceptional length and cutting them specially short in accordance with the needs of special work, as well as noted stigmata amongst clock makers and pianists.

Various authors, notably Koelsch and Kraus, have described serious modifications of the naso-buccal mucous mem-
brane accompanied by more or less typical coloration and erosion, and dental defects due to the action of vari-
ous noxious agents: acids, coloured matter, mineral dusts, chloride of lime, arsenic, dust from soda, cement, chrome, lead (Burton line), sublimate, organic sugar (dental caries due to sugar). On the other hand, mechanical modifications of the teeth occur amongst shoemakers, dressmakers, glass blowers, etc., accompanied by flaccidity of the skin of the cheeks.

Hessberg has described numerous stigmata of the antero-posterior region of the eye as well as of the crystalline lens, and J. Heller has referred to occupational deformations and modifica-
tions of the nails due to various harm-
ful agents.

Prohaska has described transversal striation, Mulzer, Oppenheim and Wolf, a dome-shaped excavation of the nails and onychosis due to the use of tur-
pentine soap, and soda amongst washergirls. In the case of leather workers, cutaneous ulcers are exhibited, and they present excoriations and small painful ulcers at their edges. Workers engaged in slaughtering ani-
mals suffer from excoriation commencing on the third finger and often accom-
pained by disappearance of half of the nail after the first month of work. These lesions generally heal after rest and may be prevented by the use of rubber gloves.

Brine causes leuconychia which is manifested by the appearance of white spots on the nail (Elsner).

Many further occupational stigmata may be noted, amongst them stigmata due to the electric current such as those described by S. Jellinek, Landois, E. Heyman, etc., as well as metallisation and various types of pigmentation and scarring subsequent to burns.

Combined stigmata are of more fre-
quent occurrence than simple modifi-
cations. Mescerski has noted among shoemakers and makers of felt slippers a type of keratosis of the palms accom-
pained by ulceration. Amongst polish-
ers of parquet flooring, there has been noted neo-formations and synovial fluid on the knees.

Amongst stone- cutters and millstone grinders such changes affect the elbows. Workers en-
gaged in spinning suffer from tricho-
stasis and melanosis due to mineral oil, with pointed formations and com-
edones covering 2 to 10 hair follicles (Fuh.s).

For mineral oil, see article "Petroleum". Among engine-drivers there has been noted dilatation of the blood vessels, traumatic scars on the hands, telangiectasis, callosities and hygroma (Mermorkij).

Combinations of black speckled tat-
toing and patches on a reddened cutaneous area with rhagades have been noted among gas workers (Oppen-
heim); among postal and telegraph employees A. Jordan reports the occurrence of callosities, cyanosis, longitudinal striation of the nail due to the use of glue and the influence of low temperatures.

Rhadages accompanied by friability of the nails and disappearance of the lines on the hands and finger tips may be noted among enamel workers and modelling designers in porcelain and china clay factories (Kavalerov and Kogan). Amongst shoemakers the
sternal region shows pigmentation accompanied by comedones and inflammatory changes such as common acne (Oppenheim).

**Prof. K. Ullmann**
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**Effects of Heat and Cold**
(Burns, Scalds, Lesions due to High-Tension Currents)

French: Lésions d'origine thermique. —
German: Thermische Hautschädigungen: Verbrennungen, Erfrierungen, usw. —
Italian: Lesioni di origine termico scol'tature, geloni, ecc. — Spanish: Lesiones de origen termico quemaduras, ecc.

Cutaneous lesions of thermic origin (including chemical burns, wounds caused by high-tension current) form a very important group in industrial pathology. These disease forms are often highly complex, being complicated by other lesions of traumatic, mechanical or physical character.

Effects due to heat sources in the strict sense of the word and brought about by high temperatures exceeding considerably body temperatures, are in general designated by such terms as "burns" and "scalding" and "catching fire"; those produced on the subcutaneous tissues by the prolonged action of very low temperatures are usually designated as chilblains, frostbite or various forms of chills.

This section is divided into three parts as follows: (a) burns; (b) chemical burns; and (c) injuries due to heat and cold.

(a) **Burns**

The surface of simple burns of the skin due to the action of high temperatures depends essentially on the physical type and constitution of the heat source in question (incandescent body, actinic radiation, incandescent metals, boilers, furnace lining, electric cushions, radiators, various substances carried to red and white heat, cinders, slag, incandescent coal and numerous heating apparatus). The materials which take effect in contact with the body are hot solids carried to red or white heat, hot liquids, gases, or superheated steam as well as ignited material and gases.

The depth and gravity of the burns, i.e. their degree, depend on the elevation of the temperature, duration of exposure and above all on the heat capacity and the state of aggregation of the burning substance. In the case of radiant heat they depend on the wave length, on the incandescence at red or white heat, as well as on the duration of the radiation.

Where the temperature varies between 50° C. and 100° C., it is the duration of contact (radiation) and especially the constitution of the skin which are all important. The thicker and the more callous the skin is, the less sensitive will be the part exposed, and, on the contrary, the more delicate and fine the skin is, the more sensitive it will be to heat. With moderate temperatures below 60° C., the age, race, habits, as well as acclimatisation to heat, the state of health, latent dyscrasia, tuberculosis, syphilis, anaemia and chlorosis, must all be taken into account. The skin and the mucous membrane throughout their extent or in certain parts develop acclimatisation to high temperatures; fakirs and professional fire-eaters and workers in many industries (blacksmiths, locksmiths and those engaged in chiselling, etc.) constitute instances of this kind. As regards radiant heat, coloured races are less sensitive than white races.

Among the most frequent cases of occupational burns and scaldings may be cited:

1. **Solid bodies**: heated metals, organic substances, silver, phosphorous and other chemical substances, concentrated sulphuric acids, sodium, oxide of calcium, slaked lime (which, under the influence of heat, enters into combination with the skin, or by rapid loss of water heats the skin); molten resins, rosins, pitch as well as bodies which solidify immediately on contact with the skin.

2. **Heated liquid bodies** which remain in a liquid state on the skin and which spread themselves over the skin according to their density; hot water, fats, oils.

3. **Gaseous bodies**, super-heated steam, air or other heated bodies, gaseous products of distillation.

4. The action of flames fed by ignition, and the transformation into a gaseous state of readily inflammable matter: wood, coal, petroleum, petrol, alcohol, gas, combustible gases alone or mixed with air; flames from welding lamps, explosive mixtures of inflammable gases with other hot substances of a solid or liquid character which exert a thermic action on the skin. As agents of this order may attain temperatures rising to 3,000° C. during explosion or ignition, an effect of even extremely short duration may give rise to deep-seated injuries.
When the heated substances exert their effect by means of contact, the aspect of the burn is usually outlined on the surface of contact. On the contrary, lesions due to flames, super-heated explosive gases or hot liquids very often show displacement of the heat source above, below or to the side, and the parts first attacked are the most seriously affected whilst those attacked later in the case of liquids for instance, the more deep-seated parts are much more slightly affected. Where it is a question of splashing of hot liquids or semi-liquid bodies, it is always the centre of each injury which is the most seriously affected part (carbonisation, scarring), whilst the peripheral part merely shows erythema at its edges.

Liquids which are poured over the clothing are apt to retain their heat and exert a much more intense effect than when the same substances are spread over the uncovered skin; scalding by hot water, alcohol, etc., causes less serious injury than hot eis liquid resin or even liquid metals. Hot water, as well as other liquids, only exceptionally gives rise to scalding of the third degree and only then when it attacks the skin for a certain time; scalding usually causes a burn of the first or second degree, the more deep-seated noted even when an entire limb has been plunged into hot water.

In the case of ignited substances, liquids or solids, small in extent but of high temperature, the injuries are distinctly outlined and are generally in the form of a crust.

In the case of gases, the gradual cooling of the gas by removal from the heat source is of capital importance in regard to the seriousness of the burns. In the case of explosions, there are not infrequently found side by side burns of varying degrees according as to whether the skin has been in contact with super-heated gases, liquids, solid bodies or explosive particles, or merely subjected to the secondary action of burning clothing.

With lower temperatures the absorption and distribution of heat on and throughout the depth of the skin exerts a perceptible attenuating influence. The thermic action is likewise modified by evaporation and humidification of the skin.

Under the action of heat, the epidermis becomes detached at certain points, becomes folded and falls from the skin in large shreds. As a characteristic sign of explosive burns and burns due to the action of flames or ignited gases, there has been noted a special radiating distribution with a clearly defined intact zone around the mouth and eyes, the play of the muscular reflexes having served as a protection to them. In the case of less serious injuries, there have likewise been remarked bands of skin of yellowish-brown colour slightly reddened alternating with lighter normal zones at the base of the folds. On the contrary, the top of the folds are discoloured, showing evidence of burning.

When particles of earth, dirt or grains of powder become encrusted in the skin, the latter shows characteristic blue-black smudging similar to tattooing, or marks produced by firing at close quarters.

Changes of the buccal and nasal mucous membrane even extending to the back of the throat and the pharynx are caused by penetration of quantities of incandescent gas, modifications which may vary in gravity ranging from whitish opacity of the mucous epithelium up to oedema and the formation of blisters, ulcers and scars.

The prolonged action of radiant heat from metals brought to dark or bright red heat as a rule merely causes formation of erythema with consequent pigmentation of the skin of varying degree, whether it be uncovered or protected by clothing. Where exposure is more prolonged, more serious injuries are encountered: thickening, dilatation of the blood vessels, warts which may degenerate into ulcerations, or cancerous tumours.

Cutaneous lesions, due to radiant heat from heating devices (Kangri apparatus used in Kashmir), and the Kairo, an earthenware pot filled with charcoal, utilised in China), or the electric radiator, may be noted amongst workers who work in the open air in the cold season and are in the habit of warming themselves by placing heating devices of this kind under their clothes or against their chests or stomachs.

Amongst the more frequent causes of burns should be mentioned: jets of steam, of boiling liquid, of petrol, petroleum, etc., and likewise explosions, contact with incandescent parts of machinery, apparatus, tools, etc., handling of molten metal (welding), boiling substances (asphalt, pitch), as well as back-firing of stoves, boilers, etc.

For electric burns, see article "Electricity".

It is impossible to enumerate completely all types of burns, whether characteristic or not, reported as occurring in the various trades or industries. Mention will therefore be restricted
Numerous injuries due to welding by blow-pipe (metal workers, tinsmiths, incandescent lamp makers, chisellers, engravers, etc.) assume the form of distinctively outlined linear burns, located on the back of the hand, on the fingers, or in the inter-digital spaces. They are of varying gravity as regards depth and generally have a small surface.

In the case of blacksmiths and locksmiths, burns are localised on the hands and forearms. They are generally restricted to blisters, and there is rarely charring.

Projections of molten metal cause burns amongst foundry workers which are slight and are localised on the top of the foot. Transporting, touching and removing pieces of hot metal in tending furnaces, as well as hammering of hot metals and spurtng of these, constitute frequent causes of burns.

The localisation and gravity of such burns vary extremely in the case of makers of precision instruments, as well as amongst cabinet workers, painters, tin founders, dentists’ assistants, workers handling feathers, etc.

Shoemakers often utilise metallic tools with sharp edges which, after heating in the flame of an alcohol or gas lamp, are used to smooth the heels and soles of shoes. These instruments slipping from the hand may cause superficial burns on the hands, fingers, and especially thumbs.

Burns are caused in hot pressers and tailors by the use of irons, and are chiefly localised on the back of the left hand. Those new to the work and liable to speeding up their work may receive burns from the hot steam escaping between the metal handle of the iron and the cloth holder, produced by the wet material. Burns localised on the hands and arms, almost invariably on the left side, usually consist of erythema and blisters.

Burns occur fairly frequently amongst bakers and confectionery makers, and are caused by flames from the oven, contact with the oven tool, or metallic closing devices in the piping, handling of working materials: liquids, hot moulds, splashing from hot masses, escapes of steam, etc. The same facts are true of cooks and kitchen workers. Most usually such accidents are attributable to haste, imprudence, or lack of skill on the part of young inexperienced workers. This is particularly the case in connection with spurtng by jets of hot steam and burns due to red hot coal and hot cinders.

Amongst washerwomen working in private houses or in washing establishments (steam laundries) the number of cases of scalding is very high.

Nevertheless, in recent years, despite increase in the number of such establishments and of the workers engaged by them, especially unskilled workers, there has been a decrease in the incidence of burns which is to be attributed to more careful training in schools providing instruction of the various occupations.

In large industrial establishments (distilleries, breweries, chemical products factories, sugar and confectionery factories, sugar and petroleum refineries, silkworks, dyeworks, etc.) workers are exposed to scalding by jets of steam, splashing due to spurtng of boiling liquids in course of transport from vats, due to the opening of valves, pipes, covers, etc. Workers may also sustain burns by falling accidentally into hot liquids, or carelessly plunging their hands or feet into these. Such cases usually consist of burns of the second degree, rarely of the third, and are usually restricted to erythema and blisters, and only exceptionally show charring. In glassworks it is usually young workers who sustain burns on the legs, but such injuries cannot be said to be typical. Amongst glass-blowers there has been noted around the cheekbone a characteristic pigmentation, ranging from reddish brown which constitutes a kind of stigmata and which persists during several years. There has also been noted a redness in the region of the nose, cheeks and around the socket of the eye. The hair of these workers becomes dry and stands on end as a result of the action of radiant heat.

In metal works and in the case of workers in the metal industry and those engaged in mechanical engineering the skin is liable to injury caused by slag and metal splashing. Even in modern factories possessing improved plant, it is chiefly reverberatory furnaces and electric furnaces attaining temperatures of 1,500-1,600° C. which cause burns, due in the first instance to the introduction of material into furnaces which are already hot, to radiant heat, and to spurtng of hot metal. Nevertheless, charging of furnaces by mechanical processes is beginning to be more and more frequently resorted to with the effect that workers are enabled to remain at a distance from the furnace doors.

During tapping of the molten metallic mass which flows in a rapid jet into the ingot moulds, it is almost impossible to avoid splashing, especially
when the liquid metal reaches the top of the receptacle, whence it is liable to spurt out. Cases of workers falling accidentally into such incandescent masses of metal have even been known to occur. The removal, by means of gripping-irons or cranes, of incandescent blocks of metals does not always prevent the occurrence of injuries which are at times serious or even fatal. During cutting, pressing or rolling of the incandescent blocks at 1,000-1,200° C., and more especially during rolling of bars which whistle through the air, imprudent workers working near these may sustain burns on the feet. Forty per cent. of all the total cases of burns occur under these conditions, whilst 20 per cent. only of the victims sustain burns during charging of the furnaces (report from the Poldi Foundry).

The location of burns on various parts of the body shows the following percentages: hands, 35; feet, 20; arms, 11; face, 10; chest, stomach, back, hips, 3-4; internal angle of the eye, 20.

This latter localisation is met with chiefly amongst metal workers and is due to flying particles of hot metal (about 300° C.), often also the caruncula and conjunctivae, and the eyelids may be affected. Amongst workers engaged in the manufacture of ingots in Martin furnaces, it is the external side of the right forearm which is most exposed to risk. Projections of slag, cinders, etc., often cause burns on the feet of the almost naked workers, who usually wear wooden clogs. Injuries of this kind are also met with in glass works.

In these industries the combined action of light and heat radiations is likewise the cause of burns during casting of the molten metal or the slag.

For burns affecting firemen, see that article.

The effect of electricity on the tissues of the skin depends on the kind of current, the intensity, the extent of the contact surface, the duration of the contact, and also on the resistance of the body. This resistance depends on the humidity of the skin, formation of horny skin, and general shock (shock amounting at times to fatal shock), that is to say, on the organic predisposition and the nervous system.

The voltage cannot provide in itself satisfactory explanation of the gravity of electrical burns. Whilst the electric arc causes injuries due purely to the action of heat, that is to say, a burn, and even destroys the clothing, a force which is purely electric or mechanical causes chemical destruction and brings about changes which to some extent are purely electrolytic.

The burns are localised usually on the limbs, the face, back of the neck, but also at times on the body, in accordance as to whether contact is effected through the unprotected hands or feet, or by accident, or falling, or finally, by the victim remaining suspended to a conductor.

(b) Chemical Burns

The various forms of radiation (ultra-violet rays, Roentgen rays and radium and mesothorium radiation) constitute a frequent cause of injuries to the skin resembling closely burns and chemical burns, despite the fact that the chemical light rays and radio-active emanations above referred to are not accompanied by any commensurable elements of heat. This is not true of chemical burns which range even to the production of charring of the skin and are accompanied by increases of temperature and which involve a disintegration and decomposition of the ionic elements with hydrolysis or dehydration, with the result that the effects produced are more or less resemble burns.

Such chemical burns of the skin permit the differential diagnosis by reason of the fact that there is central disintegration at the spot at which the product exerts its action most effectively and that around this spot there occur peripheral inflammatory reactions.

Caustic alkalis penetrate the skin most profoundly owing to the fact that they saponify the fat involving dehydration, forming alkaline albuminates, and thus causing swelling to begin with, followed by charring of the tissues.

The acids also exert a dehydrating action with even more rapid destruction of the epithelium and connective tissue forming albuminous and acid proteins. The corrosive action of organic acids is proportional to their fluidity and volatile properties; that of the inorganic acids is very different and varies according to their degree of concentration.

Chemical burning due to certain products (concentrated acids, quicklime) is due in part to the heat given off by dehydration of the tissues and hydration of the product in question. It is strange to remark that, when attacked by an acid or an alkali, the tissue heals almost immediately. Concentrated hydrochloric acid has a lesser caustic effect than nitric or sulphuric acid. Trichloracetic acid would appear to be absorbed by the tissues like phenol and acts rather as a poison of
the protoplasm. Lyes require a considerably longer lapse of time for bringing about a reaction of the tissues.

Contact with irritant chemical substances does not necessarily involve burning or chemical burning of the skin. At times special forms of cutaneous inflammation are noted.

In chemical laboratories attached to scientific institutions or factories burns may occur as the result of contact with utensils, hot metals or hot glass, by overturning or spurting of, overturning, or spontaneous ignition. Burns of a chemical nature, however, may occur as the result of contact with acids and lyes, by means of a pipette or by careless emptying of reserve receptacles containing acids, by neutralisation when effected carelessly, giving rise consequently to the sudden formation of fumes and causing spurt-ting, or stopping material, ignition of hot liquids, breaking of hot receptacles in front of melting furnaces, ignition of working clothes by flames or radiant heat, ignition of combustible, wrapping, or stopping material, ignition of rubber, fat, etc., spontaneous ignition of readily combustible liquids, coal and ether, alkali, petrol, etc.

Chemical burns on the mouth occur as a result of imprudence in aspirating acids and lyes, by means of a pipette or by careless emptying of reserve receptacles containing acids, by neutralisation when effected carelessly, giving rise consequently to the sudden formation of fumes and causing spurt-ting, or stopping material, ignition of hot liquids, breaking of hot receptacles in front of melting furnaces, ignition of working clothes by flames or radiant heat, ignition of combustible, wrapping, or stopping material, ignition of rubber, fat, etc., spontaneous ignition of readily combustible liquids, coal and ether, alkali, petrol, etc.

The development of burns of varying gravity is dependent on their extent, their degree, their localisation and even on the age and constitution of the workers. Duration of development and scarring is also subject to the influence of eventual infections. Amongst workers the danger of primary infection of wounds is not infrequently connected with the material handled or, again, also with the application of inadequate first aid, even in the case of very slight injuries. It is of primary importance that in these complications and especially infection there be a suitable therapeutic treatment (wax, ambrine, lanoline, or tannin dressing) applied immediately by trained persons, or treatment at first-aid posts. Such posts are indispensable in large factories liable to the risk of fire.

It is only under such conditions that workers may reap the benefit of the great progress realised in the therapeutic treatment of such injuries, more especially in very serious cases necessitating blood transfusion, changing of dressings and plastic operations, etc.

As a later complication there should be mentioned erysipelas, gangrene, pyaemia, but chiefly persistent suppurating of wounds and also the well-known condition of collapse due to shock and toxæmia in the initial stages, conditions which may be readily avoided or prevented, thanks to opportune treatment by factory surgeons.

**Statistics**

Burns constitute the most frequent causes of accidents. Whilst there is a certain incidence of burns amongst women in the course of their household occupations (manipulation of combustible products especially in cooking, wearing of more readily inflammable clothing than that worn by men, etc.), burns of occupational origin are due, to a certain extent, to accidents of unforeseen origin: explosions, spontaneous combustion of stores of material and, especially, short circuits. It is impossible to present here the various data available in this connection relative to the different trades and industries.

The statistics assembled, however, by factory doctors prove that it is chiefly unskilled workers, and particularly women, who are the victims of occupational burning accidents, whilst skilled workers are rarely affected. As regards small-scale industry the classes of workers most frequently affected include bakers, confectionery-makers, engravers, metal founders, tailors, bookbinders, hook makers, upholsterers, painters in the building trade, mechanics, etc.

The incidence of burns varies according to the size of the staff in proportion to the size of the establishment and the type of work effected. In industrial establishments, and it increases during periods of economic depression. Incidence diminishes in the industries enumerated above parallel to the development of more thorough factory inspection, and application of measures of industrial hygiene.

Out of 3,014 cases of accidents noted during the period 1910-1913, 144 or 4.8 per cent. were burns (North German Iron and Steel Trade Association at Magdeburg).

Out of 11,275 cases of accidental reported during five years in the German chemical industry, 1,516 were covered by indemnity; 1,275 (of which 44 were compensated) were cases of scalding and burns. Sonnenburg and Tschmarke drew attention to the fact (1915) of the very high proportion of burns in occupational accidents (3.14 per thousand) occurring in the chemical industry in Leipzig, the operations involved being highly dangerous (risk of fire). It is, however, certain that this percentage has been considerably reduced, and the same is true of industrial establishments throughout the world.

According to United States accident statistics prepared over a course of many years, burns come fourth in order of frequency, following motor accidents, falls, and drowning accidents.

Since electricity has replaced the use of lighting gas, the number of burns of the skin has somewhat diminished.

As regards the ratio between the incidence of occupational and non-occupational burns in a town or in the same country only an indirect estimate can be made, since the majority of occupational burns do not appear in statistical returns either because they are not sufficiently serious or because they have escaped

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1 These refer to both (a) and (b) above.
notification. For this reason the statistics in the annual reports of the Vienna Voluntary Aid Societies are highly interesting and show in particular the ratio between burns due purely to the action of heat and to chemicals and burns of electric origin.

Prophylaxis 1

The prophylaxis of burns, chemical burns and injuries due to electricity require, on the one hand, the installation, maintenance and periodical control of all apparatus, machines, electric plant, etc., and on the other, adequate instruction of employees relative to the danger and risks incurred by them and particularly relative to the current transformers to which they are exposed. It is necessary further to assure installation and regular maintenance of means for combating fire (hose, fire extinguishers, etc.), as well as all necessary measures capable of limiting or isolating as rapidly as possible the sources of burning, chemical burning or electric accidents, as well as means of protection for those adjoining the scene of such accidents and means of providing immediately adequate first aid for the victims. Systematic instruction, physical training and selection of workers are also essential. Constant supervision on the part of factory inspectors, factory doctors and foremen is required in large-scale industry, and likewise in small-scale industry adequate supervision by those in charge.

The use of asbestos or leather gloves, wooden clogs, high boots, leather kneecaps and gaiters, aprons and large-brimmed head gear, etc., is indispensable in certain cases and should be made compulsory.

Efforts should be made in the heavy metal trades to effect operations involving risk by the increasingly extensive application of mechanical and automatic methods. It is necessary in addition, however, that workers should, as in small-scale industry, devote attention to protecting themselves by individual devices already referred to, as well as by the wearing in certain circumstances, of goggles and helmets. In establishments in which readily inflammable or explosive material is handled workers should be forbidden to smoke and infringement of this regulation should be punishable. Wherever there is any risk of short-circuit it is essential that means of fire extinction, already referred to, should be provided, especially in the case of goods which are highly inflammable, and it is essential also that notices providing indication of the means of using these and of replacing safety devices, circuit breakers, as well as relative to the proper utilisation of machines and apparatus, should be posted up. Operations of cleaning, maintenance and testing should always be effected by trained personnel. Unfortunately, the very fact that workers have become used to the danger constitutes in itself a source of danger. It is essential that the workers should be instructed and trained with a view to developing their initiative in protecting themselves against risk.

Wireless apparatus also involves a certain amount of risk. On this account it is essential to arrange for insulation of the apparatus to prevent eventual contact with the high-tension current. It is important that the public, as well as the working classes in particular, should be instructed in the risks incurred in connection with electricity and in the best means for combating these.

In the chemical industry, in laboratories, etc., notices should be posted at points where readily inflammable substances are liable to give rise to explosion (cigar and cigarette ends carelessly thrown down); wherever danger of chemical burning exists it is advisable to provide water jets enabling the parts of the body affected to be rapidly sprinkled with water; sand should also be readily available to extinguish fire, for instance, in the case of ignition of petrol or carbonic acid extinguishers should be provided. In certain cases it is further essential to provide carbon tetra-chloride for the extinction of substances which cannot be extinguished by the water spray (petrol, carbon di-sulphate, heavy oils, naphthlene, alcohol). Carbon tetra-chloride can only, however, be used in small quantities and then only when there is no danger from the formation of phosgene.

In the storage of fine pulverised metals (iron, magnesium, zinc) and vegetable products (flour liable to spontaneous combustion) very special precautions should be taken against the action of toxic fumes (phosgen, phosorphorous fumes, etc.); adequate ventilation should be provided as well as means of withdrawal of inflammable gases; facilities for first aid should likewise be provided.

Legislation 1

Burns, chemical burns and injuries due to electricity of professional origin are

1 Refers to both (a) and (b) above.
compensated in the various countries by accident insurance legislation.

(c) Injuries Due to Cold and Frost

Occupational diseases of the skin and organs due to cold are much less frequent than those caused by heat. In factories and workshops cold plays no part, at least in regard to serious injuries except where damp, cold and the manipulation of wet materials involves frequent wetting of the hands and legs in those industries in which the work is carried out in the open and in a wet state (independent of the temperature of the surrounding atmosphere). In such cases cold may give rise to frostbite of the first and second degree. In the case of injuries due to cold and frost, predisposition, constitution, age, race, the state of the health, the complexity of the skin and other circumstances play a much more important and even predominant part than in the case of burns.

Apart from the general action of cold (see article "Temperature"), there occur persistent forms of erythema (first degree) from frostbite with or without blistering; forms of frostbite (perniosis: second degree) and cold ulcers with gangrene (third degree). There have been noted further forms of dermatitis due to traumatism caused by cold and finally nervous troubles of retarded development. Very few fatal cases of occupational origin due to cold are known.

Changes of the first and second degree have also been observed at higher temperatures exceeding 0° C., that is to say, at temperatures above the freezing-point. On the other hand, frostbite of the second degree with blistering, ulceration or gangrene are only observed at temperatures below 0° C.

The action of cold exercises its effect in the surrounding atmosphere, in the open air or in cold workrooms, especially by way of air circulation or by contact with good heat conductors such as: metal, water or in the open during a thaw when workers are obliged to work in trenches or in work of excavation. Frostbite is facilitated by inadequate footgear or clothing, especially when the former arrests the circulation and is not watertight.

Frostbite of the hands and feet are known to occur amongst soldiers, agricultural workers, foresters, gardeners, road-menders, ploughmen, night-watchmen, customs officials, policemen, woodcutters, workers engaged in removing snow, porters especially when the work is effected at night, or when the watchman sleeps in the open.

In the case of women, the wearing of inadequate clothing frequently leads to frostbite of the hands, and more frequently of the feet, the calves of the legs or the arms. It is, however, chiefly the fingers and toes which are affected.

In certain industries there have been noted serious frostbite, necrosis and gangrene of the limbs, fingers and toes, yet such conditions are rarely of purely occupational origin: porters and manufacturers of ice for the preservation of food, workers in the refrigerating industry, due to contact and transport of metallic objects, to standing or sitting on cold stones, workers working in water, agricultural workers or foresters, fish vendors, and vendors of other food products, etc. During ventilation of gas piping by means of carbonic acid snow it may happen that compressed carbonic dioxide comes in contact with the worker's fingers causing frostbite of the second degree (Oppenheim).

From the pathogenic point of view, the modifications in question are vascular in character, forms of paralysis with alterations of the colour of the skin which becomes cyanosed and assumes a blue-red colour or undergoes secondary ischemic changes ranging even to gangrene and finally necrosis of the tissues of the fingers and toes, etc.

Complications consist in necrosis, gangrene, rarely tetanus, which has, however, been known to occur during work in the open air or digging. In serious cases it is necessary to proceed with the greatest care and only to effect more extensive amputation after having circumscribed the gangrene in order to avoid further mutilation and invalidity. There has also been noted a dystrophic phenomenon for instance of the nails, with continued sensibility.

Amongst the retarded manifestations and nervous troubles should be mentioned the frequent occurrence of partial or peripheral paralyses as a sequence to nephritis due to cold particularly in predisposed individuals. The part played by the nervous system is demonstrated by the symmetry of lesions of this kind and by very distinct demarcation within certain nerve centres (internal or external edge of the foot). There have been noted, but less frequently, motor paralyses and paraesthesias.

Work in a cold damp atmosphere (cleaners, washerwomen, workers in the dyeing industry) causes zones of
anaesthesia and asphyxia of the fingers, often limited to the extremities, troubles which tend to heal when the patient abandons her occupation and submits to rational treatment.

The majority of injuries caused by frostbite generally affect the pre-cutaneous layers, the deeper seated organs remaining immune, but the skin is often also affected throughout its whole thickness. Local lesions of various origin are connected with certain parts of the skin and make their appearance regularly in the form of massive manifestations of the condition in question: redness of the face and hands in fishermen, dockers, sailors, workers in ice factories, butchers and especially shop keepers obliged to work in cold places, provides an instance of this. Further, conditions of housing and working conditions, in the case of damp cold dwellings or working places, represent a further cause of frostbite of varying degrees.

In the case of numerous workers cold merely accelerates the outbreak of a definite form of dermatitis. In this connexion may be mentioned, for instance, caloric and racemose lividity, acrocyanosis, acropaesthesias, dermatitis accompanied by atrophy, Reynaud's disease, erythremelgia, sclerodactyly, etc. In the case of these affections, the action of the cold supervenes to aggravate the neuro-trophic vasomotor predisposition. Melanodermia due to cold readily causes disfigurement and is noted amongst workers, affecting especially the face and hands. It is doubtful whether cold constitutes an etiological factor in the case of angioneurodermatitis of the toes and it is rare that workers suffer from pustulous hiemal acrodermatitis of the hands.

Statistics

It is hardly possible to draw up statistical returns relative to injuries due to cold, since the factor of temperature is of doubtful etiology and the part played by it is open to doubt on scientific grounds, especially in those rare cases in which the action of cold is due to work effected inside a factory, nor is the recording of cases occurring in the open air free from difficulty, exception being made in the case of war statistics relating to soldiers, which again merely include serious forms of injuries.

Hygiene

Local injury from cold ought to be combated by exercising care with a view to preventing arrest of the circulation by tight clothing, and the wearing of garters, and by protecting the body by means of bad heat conductors (hair, wool, etc.); wearing of absorbent mat-
Slate

French: Ardoise. — German: Schiefer. —

**Composition and Properties**

Slate is a dense, fine-grained, argillaceous schistose rock produced by compression of aluminous silicates of clays, shales and certain other rocks, so as to develop a characteristic cleavage lying at any angle to the bedding plane and causing ready cleavage into thin slabs having great tensile strength and durability. It is generally dull bluish or greenish-grey in colour though the presence of limonite or haematite sometimes renders it brownish. Cleavage is the result of subjection to tangential stresses set up by folding and recrystallization induced by pressure. Slate consists largely of fine plates of mica arranged parallel to the cleavage faces. These faces have usually a slightly silky lustre due to the abundance of minute scales of mica lying parallel and reflecting light simultaneously from their basal planes.

An additional component is quartz in minute lens-shaped grains. Minute rods or prisms of rutile are also common as well as well-formed cubes of pyrites which are often visible on the splitting faces. Chalcedony slates show elongated straight sided crystals which may be one half to several inches in length, though these are as a rule more or less completely weathered to white mica and kaolin. In other cases, more especially near mineral veins, slates are filled with blade needles of tourmaline or are calcified and impregnated with mineral ores. Much folded slates may be traversed by mineral quartz veins. Pure slate dust is rarely met with.

An analysis of slate dust yielded the following constituents, showing a higher silica content: 61.57 per cent. for red schist, and 65.42 per cent. for green schist; and also rich in alumina, 19.32 per cent. for red schist, and 19.98 per cent. for green schist.

One authority states that the dust examined microscopically appears to be made up of irregular but sharply angular particles, often serrated, while another describes the grains as being soft and oily to the touch rather than hard and inelastic.

**Industrial Uses**

Slate quarries may be above or below ground. The material is generally got by hand, but is sometimes won mechanically by channelling machines. When blasting is done advantage is taken of the natural cuts or joints and the rock is readily thrown off these. After blasting the loosened mass is detached with crowbars. Good blocks are selected and sent to the slate huts for splitting and dressing. Apprenticeship is often passed in the cutting and splitting huts at the surface, and later on the young worker descends to take part in the work of extraction.

Descent may be made in trucks, but it is more often made by ladders or steps cut in the schist. The slater is often obliged while engaged in cleaving the slate face to take up a recumbent position at the foot of a crevasse of rock. In this position he loosens the slabs of slate with his pickaxe or pick. The next process is done by means of the cutter's pick, to the accompaniment of clouds of dust produced at each stroke of the pick. The slate bed once loosened on all sides is finally replaced by a mine, breaking away in blocks.

The sawyers often have to mine the blocks as well as to cut them. Boring is done by hand or by a compressed-air borer. In hand boring the worker holds the borer, while his mate applies a hammer to it with all his strength. After each blow the borer is drawn out, bringing with it much dust. The workers who remove the debris to take the blocks to the cutting huts, climbing from the foot of the quarry to the trucks or hoists, work in the same dusty atmosphere as the extractors.

The blocks are then cut into smaller pieces weighing from 50 to 100 kg. and over. These are carried on the workers' backs to the trucks and thence to the surface. The blocks, on arrival at the cutting shop, are cut into ever thinner slices until they reach the required thickness for roofing material. This operation is effected by blockers and splitters in a sitting position. The blocks are placed between the knees and split by the use of a chisel and mallet. The dust produced as work is heavy and falls to the ground and often the blocks are wetted down with a swab or mop prior to splitting as this is essential to good cleavage.

From the blocker or bankman the block passes for further splitting to the splitter seated on a cushion or wooden seat, his legs protected by a rug from slate splinters and from damp and cold. The blocks are then placed horizontally on a vertical iron stand by the dressers who, by means of a sharp knife or cutting machine, trim the edges and make the plates into the required sizes. The cutting machine is often operated by foot power.

The remaining processes come under "mill work". Mill-men usually constitute about one-fifth of the total number of slate workers.

Slate slabs after cutting, squaring, planing, dressing and where necessary enamelling and polishing, are used for roofing, for chimney pieces, billiard...
tables, wall linings, cisterns, paving stones, tombstones, electrical switch boards, etc. Fine varieties are used for writing slates and for slate pencils. Slate is becoming less and less used for roofing owing to the increasing use of artificial roofing materials and the vogue for flat roofs.

**Working Conditions and Risks**

In regard to the occupational hazard involved, one authority states: “Taking all circumstances into consideration, slate workers are subjected to conditions highly calculated to produce respiratory diseases.” In countries where the majority of operations are performed out of doors, there is not so much risk; but where slate sawing and dressing is effected in closed shops without efficient dust removal apparatus, the risk may be considerable.

Slate workers like miners may be the victims of landslides and explosions. When descent and ascent of quarries is effected by ladders or steps cut in the schist, much additional strain and fatigue is involved. During the operation of cleaving the rock face with the pick the worker, forced often to adopt a cramped and tiring attitude in a very restricted space, may be exposed to much dust, and ventilation is often very defective. Gas from explosions lingers long in such places and helps to vitiate the atmosphere. Each stroke of the pick causes dust to rise in the worker’s face, and if he is in a hollow crevasse where breathing is difficult and therefore deep, entrance of the dust into the respiratory tract is favoured by this fact.

During the operation of boring, each time the borer is withdrawn it brings with it much dust which envelops the workers, and where a compressed air borer is used the workers are enveloped all around, one authority states: “Taking all circumstances into consideration, slate workers are subjected to conditions highly calculated to produce respiratory diseases.” In countries where the majority of operations are performed out of doors, there is not so much risk; but where slate sawing and dressing is effected in closed shops without efficient dust removal apparatus, the risk may be considerable.

During the operation of boring, each time the borer is withdrawn, it brings with it much dust which envelops the workers, and where a compressed air borer is used, the workers are enveloped in dense clouds of dust and have to change with a companion after ten to fifteen minutes. The work is more rapid and efficient than in the case of hand boring but more dangerous for those employed.

Usually workers in slate mines work in an atmosphere thick with dust, fumes and gas from dynamite and carbon lamps. The only ventilation is by a communicating gallery which does duty for a ventilating shaft. There is therefore insufficient renewal of air in heavy, unhealthy weather and the dust, along with gas and fumes from explosions and from acetylene lamps, remains suspended in the atmosphere for quite a long time before being dispersed, and the worker is thus often obliged to resume work after an explosion before the working post is sufficiently free from the products of explosion.

The workers who transport the blocks to the trucks or hoists are exposed to the same dusty atmosphere as the quarrymen and have, in addition, to endure the great physical strain of carrying on their backs blocks weighing 50 to 100 kg. or over. The blockers and splitters are obliged to adopt a very bent position which interferes with the respiratory function and favours the inhalation of dust. The shops are usually very low and badly ventilated and if the cutters may be said to be less exposed to risk than the quarry workers, they are nevertheless by no means exempt from it.

The making of marbled slate involves an additional dust hazard. Manufacture of slates for school use involves polishing (done wet), generally by a machine, and ruling also done by machine and coloured red with minium.

Alcoholism is often held responsible for the ill-health prevalent among slate workers, and while it is true that by reason of their employment, which provokes thirst, many workers are addicted to alcohol so that it may well be said to aggravate to some extent the symptoms from which they suffer, it is certainly not the whole cause of them. Heavy physical labour, often accomplished under poor conditions of hygiene, facilitate the progress of disease amongst slate workers.

**Statistics**

A statistical investigation covering the years 1855-1880 gave the average length of life of slate workers as forty-eight. More recent statistics for certain districts in Belgium (between 1900 and 1920) showed that of 189 deaths among slate workers 133 occurred before the age of fifty-six was attained, while 56 were those of workers above that age. Figures affecting one district in particular revealed 51 deaths of slate workers as compared with 188 for the male population in general. Of the slate workers in question 35 died under the age of fifty and 46, or 90 per cent., under the age of fifty-six years, while 5 alone survived it.

The deaths amongst slate workers as compared with the male population in general constituted (totalling the figures for the districts dealt with) 36 per cent. Of 561 deaths from all causes among slate pencil makers (American enquiry), 67, or 64.2 per cent., were attributable to pulmonary tuberculosis and 25 to other diseases of the respiratory organs. The average age at death of slate pencil makers was estimated to be 45.7. In 1907-1914, amongst 93 deaths of slate workers 12, or
12.9 per cent., were caused by pulmonary tuberculosis, 10 by non-tuberculous respiratory diseases, equaling 10.8 of the mortality from all causes. One authority estimates after statistical investigation that tuberculosis supervenes through contagion in one-quarter of the tubercular cases and is due to heredity in the remainder.

The mortality rate for English slate workers for the period 1910-1912 was as follows (figures relative to 1,000 living): for all causes, 896; for pulmonary tuberculosis, 220; for pneumonia, 57; for bronchitis, 25; and for other respiratory diseases, 18; for diseases of the circulatory system, 118; for chronic nephritis, 26; for accidents, 61. (See articles "Miners' Diseases" and "Lead").

Analysis of the mortality figures for tuberculosis per 1,000 living at different ages and for the same period (1910-1912) provides the following figures: fifteen years of age, 1.16; twenty years, 2.43; twenty-five years, 2.11; thirty-five years, 2.82; forty-five years, 2.83; fifty-five years, 7.91; sixty-five years and over, 7.05.

According to Collis, the total number of slate workers is not very high so that the mortality rate calculated should be accepted with some reserve. Comparative mortality rates for tuberculosis amongst slate workers is lower than that for workers in the stoneware industry (415), but very much higher than the tuberculosis mortality rate amongst workers in the lime-stone industry (159). The mortality rate for other respiratory diseases and for chronic nephritis is not high. These figures, however, do not exclude the hypothesis that, as regards the tuberculosis bacillus, dust of alumina exercises an influence analogous to that of silica dust.

**Pathology**

At forty to forty-five years of age the slate worker is often obliged, on account of poor health, to leave the quarry and return to the cutting shop, since after fifteen or twenty years of subterranean work, or even earlier, exhaustion and breathlessness set in, followed by bronchitis which tends to become chronic and later set up pulmonary infections. Slate workers' disease is a pneumaticosis due to infiltration of the respiratory organs by schist dust, which in its late stages may or may not be complicated by tubercular infection (see article "Dust").

Slate workers are described by one authority as prematurely old, breathless with the least effort, wheezing, and later subject to hectic fever, and they often die like tubercular patients between the ages of fifty and fifty-five years without necessarily the agency of the tuberculosis bacillus.

In Italy serious affections of the respiratory apparatus are fairly often met with amongst slate workers. These lesions are specially characterised by numerous centres of chronic systematised pneumonia, sometimes confined to one lobe and sometimes to several, being in direct relation to the distribution of the peribular lymphatic vessels. When there is no co-existent tubercular lesion the case presents a more or less extensive sclerosis with insufficient haematoxis and cachexia, which may terminate fatally even without the presence of the Koch bacillus. This pneumoconiotic cachexia is almost always accompanied by serious cavities (Devoto, Cesbianchi).

**Hygiene and Prevention**

Where the compressed air-borer is used a water jet should be applied to draw back the dust in suspension in the atmosphere to the hole from which it is emitted. This eliminates entirely the dust hazard, but has not been widely applied so far and is not welcomed by the workers. In general the dust hazard in quarries should be reduced by manipulating the materials in a wet state and in the huts at the surface by frequent watering of the floors and spraying material. The air of the galleries and workshops should be changed by a powerful mechanical ventilation apparatus. Electric or other lamps should be substituted for carbide lamps which give off acetylene and smoke.

Trucks should be used for raising and lowering material to minimise fatigue. Even when these are provided they are sometimes not used because employers do not guarantee them as safe. By reason of the very considerable amount of dust given off during the finishing processes in the manufacture of writing slates, in spite of the installation of exhaust slates, in spite of the installation of exhaust fans and hoods, a considerable quantity escapes and falls to the ground on account of its weight, and ventilation other than localised exhaust devices only renders conditions worse. To meet this difficulty the installation of a perforated work table provided with a water trough underneath has been found productive of good results.

Propaganda for personal hygiene amongst slate workers for personal cleanliness, prevention of spitting and temperance is required to combat the forces which lower disease resistance.

**Legislation**

See article "Stone Industry".
BIBLIOGRAPHY

See articles "Stone Industry" and "Dust".


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Soap Industry


Soaps are combinations of fatty acids with the alkaline metals, sodium and potassium, but the word "soap" is also given to combinations of these acids with various other metals, e.g. calcium magnesium, manganese, iron, and zinc.

Fatty acids occur in fats and oils in the state of glycerines. Natural fats are really mixtures of various glycerides; palmitin (glyceride of palmitic acid: C_{15}H_{31}COOH), stearin (glyceride of stearic acid: C_{17}H_{35}COOH) which are solid; olein (glyceride of oleic acid: C_{17}H_{33}COOH), which is liquid.

Soaps are, therefore, also blends of the alkaline salts of these acids.

Only the soaps made from potassium and soda are called "soaps" in the technical sense of the word; they are the only ones completely soluble in water. They contain, in addition to alkaline salts and the fatty acids already mentioned, salts of fatty acids with a lower boiling point which occur in small quantities in natural fats. They contain, further, alkaline salts of resins added in the process of manufacture, while cosmetic or medicinal soaps contain a great variety of substances.

RAW MATERIALS

The raw materials for the making of soap are: fats from all sources, the hydrates of potassium and sodium (caustic potash, and caustic soda) or the corresponding carbonates of potash or soda, and resins.

Animal fats. — The following are the animal fats most commonly used: suet of beef, mutton, goat, etc., fat from the horse and pig, and bone marrow, spermaceti oil, neat's-foot oil, fish oil, etc.

Vegetable fats. — Oils of coco, palm, olive, colza, sesame, ground nuts, linseed, hemp and the caster-oil plant.

Soap factories do not usually prepare the fats, but buy them from outside.

In order to obtain fat from the soft parts of the animal, they are treated in boilers heated by steam. During this operation the products of decomposition of the albumen and the volatile fatty acids become disengaged; this causes an offensive smell, very unpleasant for the workpeople and the neighbourhood of the factory. This inconvenience can be reduced by means of exhaust ducts which carry the charge with odorous substances to a furnace or to washing devices (e.g. Somnier system).

Establishments of this kind, however, are only permitted in districts which are sparsely inhabited. They should only be erected in the neighbourhood of large towns when the prevailing wind will cause no nuisance to the town.

The escape of the vapours must be dealt with in an efficient manner. The noxious fumes, which are given off when acrolein (see article "Acrolein") or any organic waste is burnt, must be carried off by high chimneys placed above the bars of the furnace where these materials are collected. Residual water, especially that from making stearin which is sulphurous, should be purified, as it may be a source of danger.

It is the same in dealing with bone marrow, the raw material of which gives off, before any treatment, a very offensive smell due to particles of flesh adhering to the bone.

Fat represents only about 6 per cent. of the weight of bone. It is obtained by crushing the bones mechanically, followed by steam heating, as in dealing with soft parts, or by extraction with petrol. The first method is well adapted for the making of soaps. Besides the offensive smell emitted during boiling, there are certain important factors from a hygienic point of view to be considered in the crushing of bones, e.g. it is really useful to know the source of the raw material in order to tell if it may possibly be a carrier of infectious germs. The raw materials must not be touched with the hands. Washable overalls should be available for workers, and employers should install and maintain properly-fitted bathrooms. It may be remarked, however, that factory inspectors have scarcely mentioned any case of anthrax contracted during work on bones. This is probably because workers come little in contact with the raw material.

When the extraction is done by the use of petrol, it is possible for the workers to breathe the fumes when poisoning may result which is, however, scarcely ever fatal. But the dangers increase considerably when use is made of benzol, which is notoriously much more poisonous (see articles "Benzine" and "Petrol"), or other solvents: carbon tetrachloride, etc.

In some cases the crushing of the copra (the dried meat of the coconut) has caused
It should be added that handling decomposed or rancid oils containing aldehydes and fatty acids may cause certain forms of dermatitis, known as "copra-itch". Red oil (a term usually employed for crude oleic acid) is certainly one of the commonest sources of cutaneous lesions among soap workers. Dermatitis or lead pipes. This decanting by liquefaction is carried out in a place where no one enters while the operation is going on, for it causes a discharge of steam accompanied by an offensive smell. The air of the vicinity of the machine suffered from a grave irritation, of these lyes require great care, their decomposition into glycerine and fatty acids following a combination of these acids with the alkaline metals to form soaps. The name of saponification is, however, given to various decompositions of fats, whether these decompositions are produced by any metal (calcium for example) with the formation of the corresponding soap or whether they accompany the setting free of fatty acids. Soap is still made by two old processes, which consist either in heating the fats directly with caustic alkali or in treating the fatty acids with a solution of soda. This second process is rarely employed as the fat has to be first saponified, which operation can be done in three ways: by heating with concentrated sulphuric acid, by treating with steam superheated to 315° C., or by fermentation by means of seeds of the castor-oil plant. An aqueous solution of glycerine is always obtained as a by-product. Works in which soap is prepared by heating fat with potash or caustic soda receive the alkaline lye in large iron hermetically-sealed casks. Manipulation of these lyes require great care, for they are strongly caustic. Caustic soda is sometimes received in solid form in tinned iron receptacles (soda in drums: Trommelsoda). The dissolving is in this case difficult, with risk to the skin and the eyes of workers as the addition of warm water often causes spurring.

The tallow, fats and oils are first clarified, and then purified either with sulphuric acid alone or sulphuric acid and bichromate, or by bleaching in chlorine. The products are then stored in tanks until required for use. The first operation or engouage (making into a thick paste) consists in mixing, whilst hot, fat and alkalai
in a large vat furnished with a stirrer. The materials were formerly heated over a fire; this is now done by steam. The lye should be added in small quantities, for it causes at first much frothing and the liquid rises. At the end of a certain time it simmers quietly. There is very little danger in this operation for the workmen, for all necessary precautions are taken to prevent them falling into the vat by a false step. However, there is considerable liberation of fumes and this makes it essential to carry on the process in lofty buildings where the roof has louvred outlets.

The mass so obtained still contains all the glycerine and water. The soap is separated by 
relargage, that is to say, by the addition of a strong pickle which makes it insoluble. The handling of the salt may produce with some workers wounds and ulcerations, but such cases are quite rare in soap works.

After being left to stand for several days, the lye is drawn off and the soap pumped into a mixer, which gives it a uniform consistency. At this stage are added the perfumes or other ingredients of certain soaps (sodium silicate, sodium carbonate, borax, alcohol, nitrobenzene, resins) which may be injurious to the health.

Separation by 
relargage is not always practised. It may be replaced by heating the mass which expels all the glycerine and water. The soap is drawn off while it is still sufficiently warm to be liquid.

A new method of manufacture consists in forming first a soap of lime by treating fat at 95°-100° C. with milk of lime in an iron vat provided with a stirrer. The milk of lime is prepared at the factory itself from quicklime (see above regarding the dangers of dissolving lime). The soap so obtained is cut up by a machine, and then ground in a mill. Dust formation is slight during this operation on account of the high proportion of water and glycerine in the product. The next process consists in washing with water in a vat, the bottom of which is formed by a sieve and a canvas filter; in this way the glycerine is eliminated. The mass is then carried by an Archimedean screw into a vat where it is agitated in contact with a current of steam. Soda is then added to change the lime soap into soda soap.

From the hygienic point of view this process does not differ from the preceding ones. They all expose the workers to heat and damp and may consequently be a source of rheumatic, neuralgic, myositis and other complaints. When the soap has been prepared it is cast into blocks or into bars in moulds cooled by water. It is then cut and stamped with the mark of the factory, etc. None of these operations presents any danger from the chemical point of view. The risk of accidents from mechanization is very small, except in the case of presses used to imprint the trade mark.

Nevertheless, the workers who handle the soap are liable to contract diseases of the skin. A factory inspector noticed in 1910 in Bavaria that a workman who had been employed for over 20 years in cutting bars of soap suffered from a sudden onset of a severe eruption on the hands. Special medical treatment was of no avail and the workman had to change his work. The following year, again in Bavaria, skin disease was noted as affecting two soap workers who similarly were compelled to abandon their work. In 1912 an Austrian factory inspector noticed that a workman employed in pouring the caustic lyes into the heated cauldron for 
empâtiage (making into a thick paste), according to the old process, suffered from burns on the hands and forearms. A slight modification of the process was in this case all that was needed to remove the risk.

It has been found that the acid fumes may cause erosions of the teeth and gastro-intestinal troubles.

Cramer has reported (1925) caustic burns similar to lime burns in a soap factory worker, due to "red oil" (castor oil and sulphuric acid) and followed by the loss of an eye through necrosis of the sclerotic.

Bichromate solutions and dusts can produce lesions of the skin and the nasal cartilages; and chlorine, respiratory inflammation, pulmonary oedema, and if the poisoning is serious and chronic, emphysema.

Among the various products of soaps may be mentioned soap powders or washing powders used for the making of cosmetics or for washing linen. They are often adulterated by the addition of soda. Their preparation involves risks to the health of workmen particularly in the last case, but the inhalation of soap, even if pure, is, to say the least, very unpleasant, and may irritate the respiratory channels.

The basis of the various preparations for washing clothes known as soap powders, is Solvay carbonate of soda, to which is added sodium silicate and Marseilles soap. The manufacturing process consists in dissolving the sub
stances in water in the proper proportion, allowing the whole to crystallise, and producing the product thus obtained. In 1921 Bargeron and Gandois found among women employed in this industry at Paris erosions on the back of the hands at the base of the fingers in small bleeding patches; these were due to desiccation and alterations in the elasticity of the skin by chemicals. During all these processes much dust is generated. The workmen generally protect the nose and mouth with a rag, the eyes remaining uncovered. Large masks which cover the face completely are so uncomfortable to wear that workmen cannot be asked to wear them continually. The only hygienic process consists in pulverising the soap and putting the powder in packets by means of closed-in machines connected with good exhaust ventilation. A Prussian factory inspector in 1918 wrote: “Numerous cases of irritation of the eyes have occurred, particularly among workmen employed in pulverising the soap or weighing or packing the powder. As this trouble was not noticed in time of peace, it must be ascribed to substances which, in accordance with the ordinance of the Federal Council, are incorporated with soap powder, i.e., soda, sulphate, soluble glass and kaolin.” As a matter of fact, a medical district assessor has shown that it is particularly the soda, used in very fine powder, which gets into the eyes and produces irritation. The grinding of the soap should be done in sealed apparatus, the powder being withdrawn automatically, while the workmen should wear goggles completely surrounding the eyes.

The weighing and the filling of boxes are sometimes done by machines which, however, may work so imperfectly that it is necessary after all to continue the operation of filling and to do the weighing by hand. These processes inevitably cause clouds of dust which get into the eyes of the women employed as they lean over the work table. The wearing of goggles completely surrounding the eyes has therefore been enforced for this process as for others. In addition, great cleanliness should be observed and the women employed should avoid rubbing their eyes with their hands so as not to introduce any soap powder.

In the old process a lower aqueous solution containing 2-3 per cent of glycerine is formed which is separated by evaporating the water. The process of Kreutiz provides a solution much richer in glycerine. Glycerine is used in the preparation of toilet soaps.

Special soaps (fancy soaps).—Cosmetic or medicinal soaps are usually hard soap (soda soaps). Blocks of soap are cut into slabs, then converted into shavings by means of revolving cylinders armed with blades. As this appliance may cause serious injuries to the hands, the cylinders should be protected by a device the removal of which prevents the running of the machine. The shavings are next passed between two rollers and are then welded together into a ribbon. The rollers should be guarded so that the fingers of the workmen cannot be caught. The ribbon finally passes through a drying stove where a current of hot air circulates. The drying was formerly done on screens. The material had to be turned very often and the workers suffered from the heat. This process is no longer actually used except to dry thoroughly certain soaps intended for powdering. An Archimedean screw carries the ribbons of soap into a mixer when essential oils and perfumes are added. In order to avoid possible accidents from the mixer, the apparatus should not function except when its lid is in position. The mass so obtained passes into a mixer fitted with rollers, and then, after being heated, it is converted into a band which is cut into pieces of suitable length.

The moulding of cakes of soap is done in a press. For the large size electric presses are used, but for the smaller ones the presses are worked by foot pedals. Electric presses should be furnished with protection devices. A technical study of presses has been published by the International Labour Office. Work at a foot press is fairly tiring for the workwoman, since for each cake of soap she has to make two violent movements which do not correspond to the structure of the leg (antero-posterior position with forward movement of the foot). Thus the workwoman in a day’s work of eight hours has to make more than 3,000 of these double foot movements.

The powdering of soap calls for consideration from the hygienic point of view (see above) as well as the addition of carbonate of lime, which, being done with a spade, gives rise to considerable clouds of dust. The mixture is heated in a melting pot fitted with a mixer, and colouring material or perfume is then added. The paste is then put into tubes by means of a machine from which there is little risk of accident.
The further point must be stressed that perfumes, essential oils and the various substances which are added to special soaps are preserved as alcoholic solutions, etc., which are highly inflammable. The warehousing ought, therefore, to be done in places provided with central heating. The employment of nitro-benzol fairly often gives rise to certain troubles, such as headaches, vertigo, nausea and other symptoms of poisoning by benzene.

**HYGIENE**

Soap works present a problem to the hygienist as they send out annoying and nauseating smells. Over and above general hygienic measures for the district, ventilation of the workshops, and measures against humidity, it is necessary to take a complete series of special precautions such as the installation of efficient ventilating shafts above the saponifying boilers, prohibition of discharging waste water and residues into the ground or into streams; prohibition of any accumulation of putrifying or badly smelling materials. If it is necessary to preserve these temporarily it must be insisted that they be kept in airtight vats protected against the weather. Workmen must be supplied with the tools necessary to avoid all contact with materials which are being used; also airtight gloves or failing them, ointments (neutral fats). The use of raw materials such as give off of themselves or during saponification nauseating odours must be forbidden. Precautions must be taken against fire (raw materials, essences, factory products, etc.) and dust explosions.

**LEGISLATION**

The French legislation excludes women and also youths under 18 years of age from employment in the extraction of oils contained in the greasy waters for the manufacture of soaps and for other purposes, and from workshops where sulphide of carbon is employed. In Russia the ordinance of 27 December 1924 lays down measures of special protection for the workers employed in soap factories. In Holland there is compulsory notification of diseases of the skin (eczema and dermatitis), pulmonary affections and ulceration of the nasal, palatine or buccal mucous membrane which arise among workers handling or making powdered soap. In Italy, benzene poisoning among soap workers is compensated by law.

**Social Welfare — Personnel Work**


Industrial welfare is of comparatively recent development. It may be defined as a movement directed at maintaining the moral and physical health of the human factor in production in order to assure conditions of economic health in industry.

According to an American definition, welfare comprises "anything for the comfort and improvement, social or intellectual, of the employees, over and above wages paid, which is not a necessity of the industry nor required by law".

Boettiger (1923) has defined welfare as "the effort of the employer to establish and maintain standards in respect of hours, wages, working and living conditions of his employees which are neither required by law nor by the conditions of the market".

*From the workers' point of view,* according to this author, welfare has for its object:

1. Improvement of the living conditions of workers: (a) economic advantages (minimum-wage, profit-sharing, premiums for length of service, housing, shopping facilities for foodstuffs, restaurants, canteens, etc.); (b) intellectual and social advantages (leisure, sport, clubs, instruction, collaboration in regard to social services); (c) occupational training (apprenticeship, trade schools); (d) general education and instruction (continuation schools and libraries, etc.).

2. Stabilisation of living conditions of workers and their families: (a) attempts to make work more regular and stable (research into the cause of dismissal and turnover of workers, selection and engagement of workers, etc.); (b) study of conditions of the labour market with a view to rendering work more stable (control of production, budget, etc.); (c) workers' insurance schemes (old age, accident, sickness).

3. Protective measures for the health and physical capacity of workers: (a) reduction of fatigue (study of working hours, rest periods, holidays, etc.); (b) per-

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1 In English-speaking countries the two terms used to describe this work are "welfare" or "personal work". The first expression being in accordance with English usage and the second being currently used more recently in the United States. Though both expressions designate one and the same movement founded on the same principle, they tend to become applied to varying systems presenting difference of form, scope and method.

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sonal hygiene; (c) medical treatment for sick persons and victims of accidents; 
(d) campaign against occupational diseases and accidents (ventilation, lighting, 
removal of smoke, fumes and gas, safety devices, etc.).

From the point of view of the employer, Boettiger assigns to the welfare movement the following objects:

1. Increase of efficiency by selection of workers: (a) systematic occupational training (trade schools, special methods of apprenticeship, schools for foremen, etc.); 
(b) adaptation to work (selection and vocational guidance, engagement of workers, medical examination on entry, turnover, promotions, trade analyses, research into causes of dismissal, etc.); 
(c) adaptation of the working surroundings (workers' education, schools of lan-

At the outset experiments in welfare were originally the result of initiative on the part of an employer. Robert Owen was a pioneer of this movement for introducing welfare into industry by methods which he developed at New Lanark. The seed he sowed, however, did not quicken until after being overwhelmed by the economic conditions resulting from the Napoleonic wars. It had lain buried for nearly a century. Nevertheless, certain advanced employers, such as Jean Leclaire in France, Van Marken, Storck and Company in the Netherlands, Francis Cabot Lowell, Nathan Appleton in the United States, and Zeiss and Krupp in Germany, followed in Owen's footsteps. In 1913 a conference devoted to the

Fig. 126 — Welfare building belonging to a large Swiss firm.

2. Increased efficiency by economic methods (minimum wages, profit sharing, premiums for length of service, etc.) by indirect means: (a) economic methods (pensions for invalidity, old age, benefits in case of sickness or accident, life insurance policies, stability of work, etc.); 
(b) health measures (reduction of fatigue, regulation of working hours, rest periods, holidays, restaurants, canteens, organisation of workers' leisure, workers' housing schemes, personal hygiene, medical treatment, reduction of risk from occupational disease and accidents); by collaboration with the workers in regard to social services. 

study of problems of industrial welfare met in York, at which thirty English firms were represented. This actually occurred at a time when such a thing as modern hygiene, equipment or up-to-date first-aid requisites and protection devices for the worker were unknown in industrial premises except where compulsorily exacted by legislation in a few dangerous trades, or maintained at the instigation of Government inspection departments. 

It was, however, chiefly the war of 1914-1918 which stimulated the development of this movement by again bringing into prominence the value of the
human factor, previously eclipsed by the growing importance of power machinery, at a period during which, owing to the sudden withdrawal of man-power, the need for conserving what was still available became urgent.

Welfare, which in its essence constitutes a response to the fundamental social economic and psychological requirements of the working classes, has assumed various forms in the course of its development before attaining its present stage, during which its particular character is manifested in cooperation on the part of all those affected.

First of all, as has been noted, there occurred the intervention of the employer who, moved by a philanthropic impulse to interest himself in the fate of his workers, created various schemes for assisting them which had no direct connection with work. Such were the "paternal" aims of Dale, Owen, Krupp and Lowell.

Subsequently, there was a tendency to consider efficiency in the strict sense of the word without bestowing due consideration on the personality of the worker in his capacity of eventual collaborator. It was judged sufficient to entrust questions of workers' welfare to a welfare secretary made directly responsible to the employer or general manager without any attempt to appeal to collaboration on the part of the workers.

An attempt to put into effect this latter aspect characterises, however, the third stage, during which, side by side with efforts towards increased efficiency, there has developed a tendency to take into account the harmonious development of industry as a living organism. It is this latter phase which is characteristic of welfare as understood at the present time, and it is essential to recall that the first con-

Fig. 137. — Hall of the building shown in fig. 136.
George A. Ranney, secretary of the Welfare Institutions of the International Harvester Company, which gives employment to 40,000 workers, has said in this connection that every attempt to improve industrial life should lead to reciprocal benefits. Where no benefit accrues to the employer as well as to the worker not only do such institutions lack justification on economic grounds, but further they tend to be harmful to the staff by assuming an aspect of charity or becoming imbued with the spirit of discipline based on unjustified interference in the worker's life. However that may be, it is possible to have a combination of the three stages of development outlined above, and numerous instances of this collaboration should exist between services fulfilling this purpose and medical services in the factory, works management, and production and wages departments.

The practical side of such activities may be outlined as follows: the welfare department, being notified of the need for workers for certain work, organizes selection prior to definite engagement. It thus succeeds in eliminating the futile arrival and departure, consequent on faulty selection, of newcomers likely to throw up the work at the outset, a disadvantage which certainly represents a heavy loss for the industry in general, the employers as well as the employed: slow work and waste of time and mater-

Fig. 128. — Welfare building of the firm of C. Erba and Company at Dergano-Milan. Canteen, cloakrooms, douche baths, medical department, etc.

still exist, notably in Great Britain and in the United States.

WELFARE ACTIVITIES

Activity in the welfare field is of necessity extremely extensive since it is a case of ensuring the well-being of the worker from the moment of his entry into industry, throughout his activity there and even throughout his hours of spare time and rest. On this account it is indispensable that close attention be paid to the creation of works councils, the utility of which rests chiefly in their educative value and in the fact that they bring to light the community of interests which bind employers and employed.

Medical supervision plays in this connection a role of primary importance, since the doctor must direct his atten-
tion not only to the general state of the worker’s health but also to various functional reactions connected with the kind of work on which the worker is engaged. It is interesting to recall in this connection that in the Ford factories, as a result of supervision of this type, it has been possible to give employment to 4,032 invalid workers (2,637 had lost a leg, 670 were without legs, 715 had only one arm and 10 were blind). Under similar conditions the Crane Company of Chicago, which gives employment to about 5,000 workers, has succeeded in reducing the turnover amongst its workers from 42.2 per cent. (1910) to 16.4 per cent. (1915), passing successively from 29.6 per cent. (1911), 40.2 per cent. (1912), 47.9 per cent. (1913) to 18 per cent. (1914). The Dennison Manufacturing Company, which employs 2,200 workers, has also reduced the turnover of its staff as follows: 68 per cent. (1911), 61 per cent. (1912), 52 per cent. (1913), 37 per cent. (1914), 28 per cent. (1915).

Harry Mock has stated that the profits of an establishment are proportional to the care bestowed on the health of its workers. It is precisely for this reason that any schemes of welfare should include above all general supervision of conditions of cleanliness, ventilation, lighting and heating of workrooms. On the other hand, distribution and maintenance of working suits (overalls, aprons), gloves, protective glasses, installation and maintenance of cloakrooms, lavatories, sanitary conveniences, sick rooms, ambulances, first-aid posts, rest rooms, crèches, canteens, restaurants, etc., form an essential part of this work.

Cleaning (sweeping and dusting), ventilation, lighting and heating should be effected in conformity with hygienic principles (see articles “Air of the Workroom”, “Heating”, “Industrial Lighting”). The same holds good for the equipment and maintenance of cloakrooms, lavatories, sanitary conveniences, etc. (see article “Industrial Hygiene (Workshops)”).

Choice of the best type of working clothes, protective glasses and respiratory apparatus, etc., cannot be left

![Image](image-url)
ing at the counters where the food is distributed should be obliged to take cash payment.

In dining-halls or canteens installed for thousands of workers it is desirable to simplify the service by a system of "counter service" current in the United States. The worker follows a railing which leads from the door to the shelves, whence he takes a tray; he then arrives at a counter furnished with a hot plate on which are arranged plates containing portions of food from the menu. He chooses what he wishes and proceeds to the cash box where he receives his bill before taking his shops, otherwise the workers will not be inclined to frequent them. Further, canteens and restaurants should be of ready access, and with this end in view it may be preferable to have several small restaurants than one large hall. Canteens should be furnished and decorated in a simple but tasteful manner. A badly installed canteen is likely to encourage a certain amount of negligence and carelessness in the workers' habits, whilst an attractive and carefully installed hall may on the contrary stimulate improved habits. The canteen, which constitutes a rest room as well as a restaurant, should place at table. This system has the advantage of avoiding delay and allowing the workers to choose what they want and reducing the service requirements to a minimum.

Apart from the meal hours the restaurant service should assure distribution of tea in winter or cool drinks in summer. For this purpose small tea-wagons on wheels which facilitate transport through the workshops should be used.

As regards the position of canteens, it is highly important that they should not be too far distant from the work- have comfortable seating accommodation for each worker, long benches or forms without backs being quite inadequate in this connection. Workers who have gardens should be encouraged to provide fresh flowers for the tables or, in default of these, pot plants and ferns may be used. Collis relates that he has seen very poorly installed workrooms brightened by provision of flowers cared for by the foreman, and he remarks that where it is impossible for plants to live conditions are also unfavourable for human beings.
A workers' committee should be formed to participate in the administration of the canteen and would prove highly useful for the maintenance of discipline. It should deal with complaints and organise meal-time recreation.

A well-organised factory canteen has other uses than merely a place for taking meals. The worker should, for instance, have facilities for buying for his personal use groceries and other foodstuffs from the canteen reserve, paying for these the wholesale price obtained by the management. He might also be able to obtain prepared dishes for taking to his home.

There are great possibilities for indirect circumstances, involves undue fatigue. Further, by assuring provision of good meals, much may be done in the way of preventing digestive disorders and in consequence incapacity for work or at least frequent discomfort. Indirectly also it contributes to educating the workers by rendering them more cleanly and careful in their habits and, finally, during the time spent by the workers in the canteen opportunity is provided for thorough and effective ventilation of the workrooms.

Canteens should be able to cover their expenses without either profit or loss. Certain firms place at the disposal of the canteen management not only a

CREATING THE PHYSICAL, INTELLECTUAL AND MORAL WELFARE OF THE WORKERS AND THESE PROPOSALS, REACTING ON FAMILY LIFE, MAY EXERT A VERY WIDESPREAD AND FAVOURABLE INFLUENCE. AMONGST THE NUMEROUS ADVANTAGES OF CANTEENS SHOULD BE NOTED THE FACT THAT ONCE THE WORKERS HAVE MADE A HABIT OF frequenting these they are less likely to be tempted to leave the factory and visit cafes and public-houses where they may succumb to the temptations of alcoholic excess. On the other hand, it also relieves them of the necessity of going home and returning to the factory at midday, which, under certain circumstances, involves undue fatigue. Further, by assuring provision of good meals, much may be done in the way of preventing digestive disorders and in consequence incapacity for work or at least frequent discomfort. Indirectly also it contributes to educating the workers by rendering them more cleanly and careful in their habits and, finally, during the time spent by the workers in the canteen opportunity is provided for thorough and effective ventilation of the workrooms.

Canteens should be able to cover their expenses without either profit or loss. Certain firms place at the disposal of the canteen management not only a

room, but also provide lighting, heating and service for cleaning and even advance the sum required for purchasing wholesale foodstuffs and combustibles, etc., or they may supply these products directly at wholesale prices or again they may place at the disposal of the canteen management a piece of ground near the factory for the cultivation of vegetables.

As regards health supervision of the workers, where there is not a doctor permanently attached to the factory (see article "Factory Surgeons"), there should be an ambulance, or first-aid post in charge of a nurse or a specially
trained member of the welfare staff. These should be fitted with simple first-aid equipment (medical, surgical instruments, bed, stretcher) (see article "First Aid"). The address of a doctor or doctors should be posted up and, where possible, a telephone number. The service should record and make a special study of all cases not receiving medical or surgical treatment and notify the management of the results. The management should also be in a position to know at any given moment whether the number of accidents or cases of sickness exceed the usual average.

Rest rooms, particularly useful in factories employing female workers, are often provided adjoining sickrooms and placed in charge of a nurse. Rest rooms provided with a bed or couch are of inestimable service in cases of slight indisposition (transitory headache, etc.). In this way the worker is not obliged to leave the factory, one hour's rest often sufficing for effecting an adequate cure.

In American factories three categories of rest rooms are known: "sitting-rooms" provided with armchairs, couches, tables and adorned with flowers and green plants, which the staff may use as a reading-room or centre for music and conversation, etc.; "rest rooms" properly so called, where silence is imposed and which only contain couches and armchairs; and "isolation rooms" adjoining the medical department and provided with beds for cases of indisposition or sudden illness.

Where working mothers are employed in the factory, rooms for nursing and crèches attached to the factory are of great utility. It was chiefly in France during the war that this question came before the attention of employers and the competent authority, at a time when man-power was depleted in in-

![Fig. 142. — Service for distribution of dishes in a Swiss factory.](image)
given employment in sewing rooms
where working clothes, towels or other
articles are made and repaired, or any
other easy work of this kind is effected,
for which adequate remuneration
should be paid. During this period it
would be possible to provide some in-
struction for the women relative to
their future maternity and the best
means of caring for their health be-
fore and after the birth. Efforts
should be made to encourage breast
feeding as far as possible. In certain
countries legal provisions exist which
require provision of rooms for nursing
of infants in industrial and commercial
employers most excellent results are
achieved. In proof of this, in France
and in Italy the question of breast feed-
ing is coming to be considered as one
of the most important problems con-
ected with the employment of women
in the factory.

The first crèche was organised at
Beauvais in 1846 by Dupont, and since
then the number has steadily in-
creased. More particularly in the
North of France a very rapid develop-
ment has occurred. Even before the
war it was announced at a congress
that information was available concern-
ing twenty-six State establishments and

establishments. Such an arrangement
makes for health protection of the in-
fants and at the same time is of value
in combating infant mortality. In
practice, not infrequently circumstances
concur which constitute certain diffi-
culties in achieving such objects. The
woman worker finds difficulty in get-
ting to the crèche which is placed at
some distance from the workroom, and
in consequence tires of the arrange-
ment and prefers to resort to bottle
feeding. Nevertheless, in services for
infant protection which have been
voluntarily organised by certain em-

fifty industrial establishments possess-
ing accommodation for nursing or
crèches (Feilhøen). At the present time
there may be mentioned as model
crèches those organised by the adminis-
tration of the Tobacco Monopoly in
Italy (Milan, Bologna, Naples, etc.)
(see article "Tobacco").

It is not possible to lay down fixed
principles for the best installation of
crèches. The solution of the problem
depends largely on the number of
women likely to use the room, the space
available and the type of rooms which
can be utilised and the situation of
the factory, etc. Only breast-fed children should be admitted and every effort should be made to avoid crowding and the risks of contamination involved thereby. The nursing room should not contain more than ten infants; small children should be kept away from it and should have at their disposal where possible a small park or play-field surrounded by a railing. An isolation room is advisable. Further, it is essential that a special room should be set apart for nursing mothers and that the children should wear protective overalls and should take adequate precautions as to cleanliness. The infants should be changed in a special room to which no one except members of the staff under adequate supervision should have access and in which cradles or cots are provided.

It is thus seen that a well-organised crèche involves as a minimum the following rooms: an entrance hall with cloakroom and individual lockers, a wash-basin with hot and cold water, provided with soap, nail brushes, towels, etc.; a nursing room with low chairs for the mothers and a weighing-machine; a changing room with seats, wash-basins and, where possible, baths with waste for withdrawal of water and closed receptacles for soiled linen; a dormitory with cradles, light, well aired and sunny if possible. Bedding should be simple, washable and easily cleansed. The various rooms should be centrally heated. A small kitchen is necessary for the preparation of supplementary milk, where such is considered indispensable for certain infants, and of soup and light dishes for the other children. In certain establishments there are special canteens for the mothers providing more abundant and suitable meals and drinks (milk, various infusions, beer, etc.) after nursing.

An important problem is that of the choice of staff to be entrusted with supervision of the crèche. A nurse with a special training in infant management is the best person for this task. Further, a medical specialist should visit the crèche each week or be within call in the case of suspected illness (see also article "Welfare Workers").

In certain industries or certain seasonal agricultural work in which the local labour supply is inadequate, it is necessary to recruit workers from a distance and for these it is essential that dormitories conforming to hygienic regulations imposed by law should be provided. These places should provide cubic air space not under 14 cub. m. per person. They should be well aired and ventilated and provided with windows or other apertures with mobile frames giving direct access to the outside air. Their height should be at

![Fig. 144. — "Ronuk" hall (see fig. 139) arranged for a concert (England).](image-url)
least 2.50 metres. The ceilings should be watertight and covered with a smooth coating. The exterior walls should be made of watertight material or insulating material of sufficient thickness; the flooring should be watertight and provided with well-fitting boards lending themselves readily to cleansing. The walls should be lime-washed or covered with washable paint and adequate measures should be taken for the destruction of parasites where necessary. In malarial districts special preventive measures should be taken against mosquitoes; drinking water, wash-basins with all the necessary etceteras, sanitary conveniences (shut off from the dormitories) should be placed at the disposal of the workers.

Dormitories should permit of separation of the sexes and private rooms intervals are regularly interspersed throughout the working day, where it is unduly long, or in the course of monotonous or trying work. It is of advantage to distribute to workers instructions relative to movement study and rhythm likely to facilitate their work.

The study of causes of accidents treated in the ambulance department may be of value in solving the problem of their prevention.

Finally, always in collaboration with the works management, the welfare department should impose adequate measures relative to pregnant women or convalescent workers working on short hours or half-days in order to prevent complications likely to result from relapses brought about by a long day's work. In this way it is possible

![Staff dining room and recreation hall at the works of the Gas Light and Coke Company, London.](image)

should be provided for married couples. Beds should be separated from each other by a distance of about 80 cm. Each person should have at his disposal bedding and a cupboard for his belongings. Sleeping in workrooms should be prohibited.

As regards welfare during work, responsibility for this also rests with the welfare staff, whose task it is to make the maximum effort in this direction in collaboration with the technical services.

It would also be advisable to furnish seats for workers engaged on certain types of work1 and to see that rest

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1 The German Industrial Hygiene Society published in 1929 a note on the rational utilization of seats during industrial work. Besides not only to promote partial earning capacity but also to encourage eventual return to the factory.

A welfare department can only attain maximum efficiency by the organisation of a well-conducted system of reference. An individual card should be provided for each worker bearing the date of his entry, his age, sex, results of medical examination, his work, wages, eventual changes in occupation, diseases or accidents and finally the date and the causes of dismissal. It is only by constant verification of these cards that it is possible

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1 This, several German publications, some of which are official, contain useful indications in this connection. (See also article "Personal Hygiene ")
to take account of the results of each new effort. The first result to be looked for is a reduction in the time lost by absence, in the number of accidents and in lost time in general, and, further, the direct influence exerted on output. By simple reference to figures the welfare department should be in a position to provide proof justifying largely the expenditure which it involves. It should not in any wise depend for its subsistence on philanthropy on the part of the management. Where this is the case it runs the risk of being summarily suppressed at a time when business is bad, that is to say, at the time when it becomes most necessary.

The study of the question of transport of workers by trains, trams or buses is related to general welfare. It is at times possible to facilitate arrival at the factory by obtaining slight modification of time-tables. In districts where it is possible to do so, it is often advisable to organise a motor bus service.

Visiting sick employees and workers in their homes is one of the most important tasks of the welfare department, which should obtain daily a list of workers absent through sickness. The visiting nurse should be entrusted with this activity. When good feeling exists between the welfare department and the workers (a condition essential to a well-conducted service of this kind) such visits, far from being suspected by the worker, will be welcomed. The visiting nurse should make sure that medical treatment provided in the home is effected under the best conditions, and of such a nature as to reduce duration of the illness and activate restored health, or at least bring about a return of the earning capacity. Where necessary, it is part of her duty to send the patient to a clinic or hospital, or arrange for special treatment or for

Fig. 156. — Gymnasium, Welfare Department of Imperial Chemical Industries, London.
convalescence in an institution for this purpose.

The welfare department should establish relations with various philanthropic institutions where such exist. It should keep in contact with dispensaries, convalescent homes, doctors in the district, schools attended by young workers prior to entry into the factory, employment bureaux, technical schools providing evening continuation classes, etc.

The welfare department should further encourage habits of economy, especially in the case of young persons, by establishing various types of savings banks. Social life may be rendered more agreeable by the creation of open spaces (grass parks, etc.) where children may play under the supervision of a trained person.

Cultural efforts on the part of the workers should be stimulated by instituting libraries, organising popular lectures and supplementary courses of instruction. Libraries should contain dictionaries, books of reference, and technical books dealing with the work in which the workers are engaged. They should besides contain a choice of good fiction likely to create a taste for good literature. A workers' committee should be created for the purpose of choosing the books, a system which has been found to lead to good practical results. Courses of instruction should be organised to supply the need of better technical instruction, and it may here be recalled that many employers in industry have organised real trade schools for their apprentices and workers.

Workers' gardens constitute an excellent means of recreation. The welfare department is in a position to encourage their development by seeking facilities for obtaining small allotments of ground, by buying manure and seeds at wholesale prices, and by organising competitive flower and vegetable shows, etc.

The welfare department may again
encourage the organisation of consumers’ co-operative societies, the utility of which it is hardly necessary to insist on. Such societies, by suppressing the profits which accrue to the middleman, are of value in the campaign against high prices.

Shops most frequented by the working classes are grocers, butchers, pork butchers, fishmongers, and, apart from provision stores, drapery and shoemakers’ establishments. It would be advisable, therefore, to stimulate the convenient grouping of such shops to facilitate shopping in centres possessing adequate transport facilities.

Finally, there should be mentioned amongst social efforts calculated to contribute to the well-being of the workers the example of certain employers who have organised industrial orphanages or funds for providing sums of money in cases of marriage or for providing family allowances. These latter constitute a very effective means of combating depopulation. In this connection may be cited the procedure followed in a large French factory. Considering that the daily wage of a good worker should suffice to feed his family, however numerous it be, this factory has decided to grant large allowances to its workers. In 1926 these allowances amounted to 75 francs per month for a child under sixteen, 150 francs for two children, 300 for three children, and so on, with a monthly increase of 100 francs per child above that number. The same establishment grants birth premiums to its workers, 400 francs for the first child and 250 for the following children. The system is completed by allocation of benefits in the case of absence from work on account of pregnancy, premiums for nursing mothers, and reductions in the rent of workers’ dwellings.

RELATION BETWEEN THE WELFARE DEPARTMENT AND THE MEDICAL SERVICE IN THE FACTORY

The field of action of a welfare department in industry such as has just been described is very much more extensive than that pertaining to the medical service. Nevertheless, their common aim is the maintenance of the workers’ health. It is therefore highly important that the relation between these two departments should be clearly defined. Generally speaking, where

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**Fig. 148.** — Bedroom in the Swiss welfare building shown in figs. 136 and 137.
there is a permanent medical service, final decisions should admittedly be left to it. A few examples may serve to illustrate in what manner these two departments may collaborate where the medical service is only intermittent. The doctor is called upon for his advice, for instance: before the engagement of a candidate for work, who has to be medically examined; in regard to measures to be taken to prevent propagation of infectious diseases; in regard to measures of cleanliness and prevention of occupational diseases, more especially where workers, by reason of the nature of their work, are brought into contact with harmful or irritant products; in regard also to improvements to be effected in apparatus and devices for eliminating dust, smoke, etc.; in regard to the necessity for leave or for rest in a convalescent home; in regard to the length of the working day to be fixed subsequent to an accident or illness; and in regard to reasons in favour of a change of occupation on health grounds, etc.

In each case it is the task of the welfare department to ensure that medical advice is faithfully followed, and in a certain measure to render assistance to the doctor in his work. It possesses further a large sphere of activity which is quite outside the sphere of the medical service. Nevertheless, those directing these two services must never lose sight of the fact that they have been created with a view to maintaining and improving economic health in industry and safeguarding the physical and moral health of the worker.

SOCIAL WELFARE IN VARIOUS COUNTRIES

Social welfare has, at a more or less rapid pace, made great progress in the majority of industrial countries, in which it naturally has assumed varying characteristics peculiar to the country concerned. Thus, for example, in the United States, it demonstrates a tendency towards assuring better adaptation of the worker to his job. In Great Britain, its aim has rather been to establish more satisfactory relations between the management and the workers. In France, Belgium and Italy it is characterised by special interest devoted to health conditions and social surroundings (dwellings, family life) of the wage earners.

The importance of social welfare in industrial or commercial establishments varies accordingly from one country to another.

In Belgium a recent enquiry (1930) undertaken by Langelez, comprising 2,555 factories and 494,412 workers belonging to the most varied industrial groups, has furnished the following data: in 480 factories (31 per cent.) aptitude for work is made the subject of examination on engagement; medical examination takes place in 497 (22 per cent.) on admissions.

Fig. 149 — Workers' dwellings in Switzerland.
of apprentices, and in 472 (21 per cent.) on engagement of adults.

Medical examinations are periodically effected in a number of establishments liable to special risk. One hundred and twenty-four establishments, 10 of which are coal mines, engage visiting nurses, and 43 welfare supervisors, entrusted with the physical and moral welfare of the workers and with visiting the workers' homes, etc.; 174 factories provide first-aid in case of accident or sickness, entrusted to certifying surgeons; in 16 establishments, 14 of which are coal mines, there is a permanent medical service, and 269 dispensaries or sick rooms, and in 30 cases radiograph departments have been instituted. In 22 cases there is an electromecano-therapeutical service, and in 19 cases a room for treatment by ultra-violet rays; 37 factories make provision for hospital accommodation for victims of accidents, despite the absence of a fully equipped hospital; 219 have their workers cared for at a factory dispensary, and 35 establishments have organised surgical treatment for troubles unconnected with occupational accidents. In 15 factories the members of the worker's family enjoy similar advantages. The latter services are in 30 instances free of charge, and in 10 instances subject to financial participation on the part of the workers.

In connection with treatment of disease, the Belgian worker has recourse to medical and pharmaceutical treatment by belonging, together with his family, to mutual insurance schemes. Services for treatment of sickness, which still exist, represent merely a survival of older conditions. There still exist 128 such services for treating sickness, amongst workers only, and 98 for workers together with their families. In 18 cases free service is provided, and in 62 cases on payment of fees; 250 factories grant financial help to sick workers, and 76 coal mines, by means of a convention, assure their workers 20 to 35 per cent. of their wages in case of illness. In 275 factories special grants are made to women workers or wives of workers during pregnancy; 454 factories possess canteens for the workers; 533, cloak rooms; 1,057, wash basins; 111, douche baths, quite apart from establishments where installations of this kind are imposed by law. Efforts in welfare are further manifested by creation of the following institutions: 5 maternity centres, 7 crèches, 4 centres for nursing mothers, 23 centres for infant care, 58 parks for sport, 54 savings banks, 44 open-air colonies, and 374 schemes for paid leave. Finally, 149 factories have instituted schemes such as pensions schemes, lending schemes, schemes for construction of workers' dwellings, facilities for gymnasiums and entertainment, musical and dramatic organisations, etc.

In France an enquiry undertaken in 1927 by R. Würtz into hygiene and welfare in the workroom, and covering 32 large establishments, has revealed the fact that the majority of industries have bestowed their attention on hygiene in regard to workshops (construction, equipment, cleanliness), on workers' diet (canteens, restaurants), on sport, the prevention of accidents, and on the establishment of medical services and crèches. In a great number of cases the chief of the staff fulfils the functions of welfare superintendent. In certain factories a special manager, designated as "welfare manager", is entrusted with the creation and control of such institutions, and is responsible for their working. His task is that of constantly ascertaining the necessity for and, where possible, carrying into effect of anything which may contribute to improving working conditions. In other establishments a welfare super-
intendent is entrusted with the supervision of social schemes in the factory and their good management. She is likewise responsible for maintaining contact with other municipal schemes of a private or public nature, for looking after the workers' families, pregnant women and infants, and for distributing birth and nursing premiums accorded by industrial societies. Her role is that of serving as an intermediary between the factory management and the employees.

In certain factories—such as, for instance, those of the General Company for Locomotive Construction at Nantes—a special welfare superintendent is appointed to look after the working class suburbs belonging to the Company. Würtz expresses the desire that in all industrial enterprises of a certain size a welfare superintendent should be appointed, enjoying the rank and remuneration of a department manager, directly responsible to the employer and entrusted with the study and practical application in the factory of all questions relating to hygiene, safety, welfare and training of the staff. On the other hand, he suggests the creation of training centres or courses of instruction intended to provide training for welfare supervisors, and more generally for stimulating development of the welfare spirit amongst factory managers.

In Great Britain the welfare movement arose during the war, at a time when the large munition factories were very restricted for man-power. The Health of Munition Workers' Committee having drawn attention to the importance of the well-being of the workers, a service was created within the Ministry of Munitions and entrusted with the study and realisation of certain measures proposed. The work was mainly concerned with women and young persons, and much less with men. It dealt with needs both inside and outside the factory.

Welfare within the factory comprised supervision of general working conditions, engagement and selection of workers, their transfer from one department to another, progress of apprentices, questions of dismissal, and, in general, all questions relating to the human factor. The official in charge of the welfare department was likewise called upon to devote his attention to hygiene in the workrooms (cleanliness, ventilation, heating, seating accommodation, etc.), canteens and first-aid posts. He had to keep a record of cases of sickness and of accidents, and he was responsible for distribution of working clothes and for supervising cloakroom accommodation, lavatories, and sanitary conveniences.

Outside the factory, the activity of the welfare department was directed to the housing problem, to the provision of facilities for transport for going to and coming from the factory, to visiting the sick, to the creation of scout organisations and the institution of recreation of all kinds, to education and instruction of the workers, and to the employment of means tending to improve their economic conditions.

Commencing with the pre-war period, conditions relating to the allocation of creches for breast-fed infants in factories were studied. Committees including workers' representatives were constituted in order to assure from the outset the support of the workers. In this manner the welfare project was facilitated and many real or imaginary obstacles were overcome.

Efforts made during the war have left an indelible mark on the outlook of the employers, and even to-day, despite the industrial depression, there exist at least a thousand large enterprises possessing welfare departments.

In the coal mines the movement in favour of workers' welfare is based on a law passed in 1930 which created a fund drawn from rents paid to the mines and proportional to their output. This fund was intended for social welfare, schemes of recreation and improvement of workers' conditions, both inside and outside the mines.

The sum devoted to this purpose, amounting to £1,000,000 per annum, is controlled by a central committee composed of representatives of miners and of employers. In principle four-fifths of the sum collected must be spent in the district from which it has been drawn, the remaining fifth being contributed to objects of general utility to the industry.

In practice the central committee is advised by a local committee of workers and employers as to the manner in which the sums collected should be spent in each district.

Up to the end of 1925 money was expended in acquiring sports grounds and creating various institutions (£2,000,000), in providing sanitary installations, convalescent homes, ambulances, sick rooms and douche baths (£1,000,000).

A fifth of the sum, which for the first five years amounted to £1,000,000 was spent as follows: 50 per cent. on research relative to hygiene and safety, and 50 per cent. on instruction for the mining population.

In Italy, an enquiry made in 1923 by the General Department of Labour provides an account of the state of development of institutions for workers' welfare. In 872 establishments giving employment to 333,410 workers, about 120,000 of whom were women, the following manifestations of the welfare movement were noted: medical treatment (723 establishments); paid holidays (523); organisation of special hygiene measures (759); canteens and soup kitchens (427); mutual benefit funds (321); libraries (32); rest periods within the factory (133); special installation of washing accommodation (523); installation of douches and baths (163, with 265 baths and 314 douches); cloakrooms for coming and going to and from the factory reducing the working hours prior to leaving the factory in order to permit of the workers attending to the needs of personal hygiene were accorded in 341 factories. Out of
427 establishments which had instituted canteens, 137 possessed soup kitchens, under the direction of the factory management in 37 cases, and run by the workers in 39 cases, etc. According to a report published by Mr. Olivetti (1928), the institutions provided by employers in activity between 1923 and 1927 were as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Mutual benefit funds</th>
<th>Workers’ dwellings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1923</td>
<td>221</td>
<td>35</td>
</tr>
<tr>
<td>1924</td>
<td>227</td>
<td>36</td>
</tr>
<tr>
<td>1925</td>
<td>222</td>
<td>36</td>
</tr>
<tr>
<td>1926</td>
<td>225</td>
<td>38</td>
</tr>
<tr>
<td>1927</td>
<td>227</td>
<td>38</td>
</tr>
</tbody>
</table>

Savings banks
Sports clubs
Libraries
Reading rooms
Courses of general culture
Primary schools
Maternity schools
Trade schools

In the Netherlands welfare methods were introduced fifty years ago in the factories of I. C. Van Marken, Delft, and in the factories of Storck and Company at Hengelo. These measures included improved working conditions from the health aspect; treatment for sick, incapacitated and aged workers; construction of workers’ dwellings; provision of reading rooms, and organisation of evening entertainments; the institution of committees representing the interests of the worker within the management; and, finally, the creation of a printing works which has since become the property of the workers.

In Sweden the metallurgical trades have for the past fifty years possessed typical welfare institutions run by the employers on paternal lines. At the present moment welfare supervisors are appointed to run institutions of this kind. There is at present a marked tendency for the municipal authorities to take over this work originally instituted by the employers.

In Switzerland very remarkable work has been effected by the Volksdienst, the object of which is to improve the moral and material conditions of workers.

On the other hand, almost all large industrial establishments possess welfare funds (Wohlfahrtsfonds), intended for the creation of social schemes run by the factory or as a subsidy for existing schemes (crèches, holiday colonies, etc.).

In India social welfare has largely developed since the end of the war, and its object at the present moment is that of obtaining improved material conditions for the workers. This task is generally in the hands of organisations which are independent of the factories, such as the Y.M.C.A.

In Japan the Government enquiry effected by the Prefect of Osaka, covering 281 industrial establishments employing each upwards of 100 workers, showed that already in 1919 certain measures were taken for promoting workers' welfare. These measures concerned distribution of the most necessary foodstuffs (popular restaurants, provision shops, etc.), housing of workers, medical treatment and sanitary installations, encouragement of thrift and insurance, financial assistance and mutual insurance schemes, instruction, organisation of workers' spare time (clubs, excursions, theatrical entertainments), crèches, provision of legal advice, etc. In 1927 the Government decided to allocate 100,000 yen per annum for the encouragement of sport in factories and mines.

In the United States an enquiry undertaken by the Labour Bureau and published in 1927 shows the development of measures adopted in various factories with a view to promoting the comfort and recreation of workers. Out of 430 establishments, giving employment to 1,977,000 workers, covered by the enquiry, 235 provide clubs, reading, recreation and billiard rooms and gymnasiums for their workers, 318 organise conferences, cinemas or concerts and furnish funds for creating orchestras.

In the course of the enquiry a certain number of industrial employers stated that they were averse to introducing any institutions of this kind in order to avoid the impression that they had any desire to interfere with the independence of their staff. Others, on the contrary, were of the opinion that all efforts with a view to promoting distraction of workers during their spare time are well received and succeed provided the workers themselves have a final say in their organisation. Finally, certain employers stated that they had been obliged to abandon entirely or partly such attempts because their workers did not take sufficient interest in them or because the expense involved was out of proportion to the results obtained.

In the majority of establishments the types of insitutions which render the greatest service are rest rooms and recreation rooms.

The following figures give an idea of the importance which a large American undertaking, the Steel Corporation, accords to workers' welfare. Sums destined for the organisation of these schemes appearing in the budget from 1 January 1912 to 31 December 1925 are as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Playgrounds, schools, clubs, gardens,</td>
<td>$27,070,411</td>
</tr>
<tr>
<td>Visiting nurses' expenses, etc.</td>
<td>$31,721,031</td>
</tr>
<tr>
<td>Sanitation</td>
<td>$15,690,604</td>
</tr>
<tr>
<td>Relief for injured men and families of men killed</td>
<td>$45,060,601</td>
</tr>
<tr>
<td>The employees' stock subscription plan</td>
<td>$92,564,858</td>
</tr>
<tr>
<td>Total pensions payment to employees, additional benefit payments</td>
<td>$6,670,452</td>
</tr>
<tr>
<td>Creation of a permanent pensions fund</td>
<td>$8,000,000</td>
</tr>
</tbody>
</table>

Total 155,988,048

There should be added to this, over and above the total, pensions paid to employees amounting to $13,014,843 and other funds for indemnities and administrative expenses giving a total of $509,338.
In the Ford establishments the Social Welfare Department gives employment to 400 persons and is organised in seven sections: employment bureau, welfare superintendence, a school for the English language, medical service, sociological service, safety service and legal service. The first three sections come under the general management, whilst the last four are under the direction of a single manager, though they remain quite independent as regards their action.

Finally, to quote another example, may be mentioned that of the National Cash Register Company, which possesses a welfare department comprising various sections: health and safety, education, instruction, etc.

LEGISLATION

In numerous countries social legislation in force comprises the majority of measures above referred to with a view to the protection of health and provision of hygienic surroundings for work (see articles "Personal Hygiene" and "Industrial Hygiene (Workshops)"). Special Orders ("Welfare Orders") have been issued in Great Britain, acquainting employers with their responsibilities in regard to the creation of installations for the welfare of their workers (canteens, provision of drinking water, working clothes, washhouses, cloak rooms, first-aid posts). Legislation in several countries provides for the creation of crèches: Argentina (1924) (industry and commerce, where over 50 women are employed); Brazil (1924) (industry and commerce); Colombia (1924) (establishments giving employment to upwards of 50 women); Denmark (1913) (establishments employing upwards of 25 women); France (1928) (industry and commerce, upwards of 100 women); Italy (1927) (industries employing at least 50 women); Peru (1925) (establishments employing upwards of 25 women); Poland (1927) (industry and commerce, where upwards of 100 women are employed); Portugal (1927) industries giving employment to upwards of 50 women); Rumania (1928) (industry and commerce, employing upwards of 50 women); Yugoslavia (1922) (industries in which upwards of 100 women are employed). Finally, special Acts are devoted to the protection of women (see article "Women's Work") or the organisation of workers' spare time (the Dopolavoro organisation in Italy, etc.).

In the field of international industrial legislation the majority of Conventions and Recommendations adopted by the International Labour Conference may be considered as measures calculated to promote workers' welfare. Special mention should further be made of the Recommendation adopted in 1924 dealing with workers' spare time, which recommends that: * having due regard to the requirements of different industries, local customs, and the varying capacities and habits of the different kinds of workers, consideration should be given to the means of so arranging the working day as to make the periods of spare time as continuous as possible; that by means of a well-conceived transport system and affording special facilities in regard to fares and time-tables workers should be enabled to reduce to the minimum the time spent in travelling between their homes and their work; as well as the encouragement of individual hygiene by provision of public baths, swimming pools, etc.; the encouragement of legislative or private action against the abuse of alcohol, against tuberculosis, venereal disease and gambling; the increase in number, if necessary in co-operation with the national or local authorities concerned, of healthy dwellings at low rents. *

The Recommendation further provides for *improvement of the workers' domestic and family life (gardens, allotments, poultry keeping, etc.); the development of the physical health and strength of the workers by means of games and sport, and the extension of technical, domestic and general instruction, etc.; the encouragement of legislative or private action against the abuse of alcohol, against tuberculosis, venereal disease and gambling; the increase in number, if necessary in co-operation with the national or local authorities concerned, of healthy dwellings at low rents. *

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Prof. E. L. Collis

(Cardiff)
Sodium

French: Sodium. — German: Natrum. —
Italian and Spanish: Sodio.

Sodium, symbol Na, is very abundant in nature and is found in a state of combination in numerous ores (cryolite, glauberite, borax, etc.) and more abundant still in the form of chlorides (rock salt, sea-water, which contains up to 3 per cent.), sulphate, carbonate, double fluoride of sodium and aluminium, of nitrates (sodium nitrate or Chili saltpetre).

Sodium was prepared in a free state for the first time by Davy by electrolysis of the hydrate of molten sodium. Industrially, all sodium is now prepared by electrolysis of caustic soda or solutions of chloride of molten sodium. Molten lead is used as the cathode with which the sodium liberated passes into the alloy. The latter passes into another compartmert in which the molten caustic soda acts as an electrolyte. The alloy then acts as the anode and all the sodium is deposited at the cathode without any consumption of NaOH. Several methods of electrolysis of chlorides of molten sodium are known, but do not seem to have replaced the caustic soda method.

Metallic sodium has a silvery aspect and a density of 0.97. It melts at 97.6° C. and boils at 742°. Sodium is used in the preparation of silicon, magnesium, peroxide and cyanide of sodium, sodium amide and certain colouring matters. It is also used for freeing petrol from sulphur.

In the state of pure metal it may cause burns when it comes into contact with clothing or damp skin (chemists, students, laboratory attendants who have to manipulate sodium: Egli-Rust). From the point of view of industrial hygiene, it is the combinations of sodium which are of interest by reason of their caustic action (caustic soda) or irritant action (sodium chloride). (See also article “Alkali”.)

In connection with alkaline chlorides may be recalled necroses of the skin amongst workers occupied in the transport of sacks of kitchen salt, which have been described by Somogyi. As regards the hydrate of sodium (caustic soda) and carbonate of soda, mention will here be confined to a few instances. The former exercises violent caustic action, and there have been noted cases of injury to the eyes and visible mucous membrane as well as to the skin where these have been exposed during a certain time to the action of the hydroxide. In view of the widespread application of this substance in industry and chiefly in organic and non-organic chemical technique, it is of first-rate importance that the attention of those called to manipulate it should be drawn to the relative precautions which it is advisable to take. It should be stated that in daily practice a crude product is used which is a mixture of soda and caustic potassium, the latter possessing besides similar properties and involving the same risk and danger as caustic soda.

As regards the carbonate of soda there have been reported cases of caustic burns affecting workers in soda factories, caustic burns chiefly situated on the nasal mucous membrane, recalling thus the injuries caused by chromates (Müller and Fischer). Derangements of the digestive system have been met with amongst workers engaged in manipulating carbonate of sodium and sulphide of sodium as a result of swallowing of dust containing these substances (Roth).

In the soda factories of Beresnikow utilising the Solway and Loewy processes, Noworassow found in 1930 that the atmosphere close to the caustic soda boilers contained 0.0033 to 0.041 mg. per litre of this substance. The caustic action was however slight, and at a distance of 3 metres from the boilers transformation into carbonate of soda commenced to take place.

For further data see articles “Alkalis” and “Chemical Trades”. For injuries due to chloride, bi-chromate, sulphate, cyanide and sulphide of soda, etc., see articles “Chlorine”, “Chromium and Chromates”, “Sulphur Mines” and “Cyanogen and its Compounds”.

The irritant or caustic action of the compounds of sodium affects very often the visible mucous membranes and in particular the ocular conjunctivae (chloride of sodium noted amongst workers engaged in spinning and dipping flax: P. White and Müller), and naturally also on the skin: bi-carbonate of soda (papular eczema affecting chemists and druggists; sulphate of soda affecting persons engaged in cotton-dyeing establishments: P. White); phenolate of soda — at the moment of crystallisation of the naphthalene; cyanide of soda (dermatitis localised often on the genital organs), etc. There should in conclusion be recalled serious injuries, especially of the genital organs due to small fragments of caustic soda when it is used in a solid state.
For compensation for injuries due to caustic soda, see article "Alkalis". Those due to chlorides are accorded compensation under Russian legislation when it is a case of dermatitis. Those due to sodium sulphide receive compensation in Switzerland.

Soldering, Welding, Burning or Coating with Lead


"Lead soldering" is a term given to work involving the use of metallic lead, either in the construction of cisterns, containers and piping, which is carried out by uniting separate pieces of sheet lead, lengths of piping, etc., by means of a blowpipe, and is lead soldering in the strict sense of the word; or, in lining wrought-iron or cast-iron utensils with an adherent layer of lead by the aid of a blowpipe (Homogen-Verbleitung).

This article will not include soldering done on tinware with a blowpipe, where lead or alloys of tin with a more or less high percentage of lead are used as superficial solder for uniting various metallic parts.

From the sanitary and hygienic point of view, these operations are different from actual lining or coating with lead.

In a broader sense, may be included soldering work carried out with a blowpipe when fitting lead pipes or attaching to them tinware or "sheeting".

To the industrial hygienists, soldering carried out as a special trade for long periods of time, and, generally, in special factories, presents a certain interest.

It is therefore essential to take into consideration the lead-lining of articles for the chemical industry, particularly that which is carried out in large factories and chemical works (the aniline dye and synthetic ammonia industries), and in special soldering concerns working for the chemical industry, and, upon a less extensive scale, soldering and lead lining in other industries, such as the manufacture of electric batteries.

**TECHNICAL OPERATIONS**

In the chemical industry light lead-lining is employed as much as heavy lead-coating. In factories working for chemical industries it is particularly lead-coating which predominates. Superficial lining or lead-surfacing is employed for re-coating and re-surfacing cast-iron containers, reaction and distillation vessels and evaporating and crystallising dishes. The construction of large lead chambers, for the manufacture of sulphuric acid, obtained by soldering together lead sheets, also comes under the heading of lead-surfacing and lead-lining; lead-coating is utilised chiefly in the construction of apparatus designed to withstand high pressures and temperatures, such as autoclaves, apparatus for working under steam pressure and for use in the construction of armatures and agitators.

The material employed in these various processes is almost exclusively soft lead. For the construction of apparatus used in the food and the pharmaceutical industries, lead is replaced by pure tin.

The technique of the work in the two forms of lead covering is profoundly different. For lead-lining a lead sheet is moulded to the shape of the container by hammering and beating, and introduced into the container. It is fixed by folding over the overlapping edges and finished off by burning together the edges of the lead sheets. This work is carried out almost exclusively with a comparatively small oxyhydrogen flame; but more rarely a flame of hydrogen and compressed air or of coal gas and compressed air is employed; in this case, the temperature ought not to be above that which is just necessary for melting the additional metal and the edges of the lead sheet. Lead-coating consists in doubling an iron surface with a layer of solid lead by establishing an intimate fusion between the tin lead-coating applied to the iron and the lead. The thickness of the lead in this case may be as much as 10 mm. thick. For this purpose the surfaces of the iron object are prepared beforehand; that is to say, they are treated with dilute hydrochloric acid or "pickled". In the case of small objects, such as piping, after the acid bath, the surfaces are tinned by immersion in an alloy of molten lead and tin (80 per cent.), in order to facilitate the adhesion of the lead layer. This is done in two ways, one of which is only used for external coating, whilst both methods are applicable for internal coating.

In the method used for both categories of lead covering, the molten lead is poured in sufficient quantity in a thick layer upon the surface, which has been prepared and treated with sal ammoniac or other flux. The layer is then intensely heated with the blowpipe, which is moved about over the surface to smooth it and to form cohesion with the underlying tin or tin lead-coating.
By using powerful flames and sometimes lightly stirring about with an iron wire, the required rise of temperature may be expedited in the underlying layers.

When it is a matter of lead-coating of cylindrical interiors, those parts of the interior surface which are to be submitted to the operation is brought into position by rotation and outlined by wires; this permits of successive coating of the whole interior surface. After these operations, the layer of lead often appears in sections of polygonal form, which, after cooling, necessitates a further operation to restore the interior of the pipe to cylindrical form. When it is a question of covering a concave cavity, an arrangement is used which allows for tilting the cavity in such a way as to bring successively all the parts of the surface into a horizontal position.

In the method which can only be used for external applications, lead, in the form of little strips, is melted by the blowpipe as required and dropped in small quantities upon the tinned iron surface, where it is melted together. Treatment of the leaded surface with the blowpipe flame then ensures that all irregularities are obliterated. This method can only be employed for the external soldering of pipes and agitators or for uniting parts of apparatus which have previously been submitted to the process of lead-coating.

A secondary operation, but an important one from the hygienic point of view, is the removal of old layers of lead prior to renewal. This work is done by “burning off” i.e. by melting the surface by means of a powerful blast on the leaded surface.

The flames generally employed in the various operations described above are preferably the oxyhydrogen or the hydrogen-compressed air flame; this latter is particularly used for burning off; more rarely the oxy-acetylene flame is used, or that of coal gas and oxygen or coal gas-compressed air.

In these cases the jet employed for external plumbing is of small dimensions, but it is larger for internal plumbing and burning off. The use of electric arc “jets”, or of electric soldering apparatus is still in the laboratory test stage at present. Nor has the replacement of lead-coating by metallisation (see that article), which would present hygienic advantages, for the stream of lead cools down immediately, yet been used for plumbing in thick layers.

Mechanical processes are only used for lead-covering of the inside of pipes; in this case the molten lead is poured between the interior tinned surface and a mandrel inserted into the bore of the pipe.

In the manufacture of electric batteries, lead soldering is in the first place employed at the junction between positive and negative plates, and for soldering the lead rod which serves as an electrode. The soldering is effected with the assistance of a small flame which melts a little strip of soft lead placed between the joints of the prepared and formed plates.

In the second place it is quite usual for lead soldering to be applied to the interior of battery cells, made either of wood or some other material. In this case the work corresponds in principle to that of lead lining. The lead sheets, having been fitted to the interior surface of the cell, are soldered along their interior joints with a small blowpipe, or else the forms destined for lining the cells may be moulded beforehand, and the sheets, which compose them, soldered along their joints prior to being inserted in the case.

In certain American factories, a mechanical method is used whereby the edges to be soldered are fused together with a pointed flame (A. Hamilton). The hydrogen-compressed air or the oxyhydrogen flames are chiefly used; less often the coal-gas-oxygen or the acetylene-oxygen flame.

Sources of Danger

Soldiers come into direct contact with cold sheets of lead; but lead poisoning does not originate in this way, as is known from the immunity of men who handle sheet lead in the manufacture of sheet lead and lead piping. Exposure to lead dust is a different matter, and a serious hazard which plays a part when adjusting sheet lead covered with carbonate of lead, and, in particular, during the operation of removing the parts affected by corrosion and formation of sulphates, or during repair work. But it must be added that even in these cases the risk of lead poisoning is relatively reduced. This risk is greater during the operations of lead-coating when, because of the raised temperature, there is volatilisation of the lead and danger of inhaling “lead fumes”. The importance of this risk is clearly revealed by comparing the large number of cases of lead poisoning among men who work at lead-coating, with the number among workers who carry out lead-lining or merely the operations which precede the latter, such as transport, cutting up, and shaping of lead sheets. The greatest part of the lead-lining process is represented by mani-
pululating cold lead, while the soldering proper and the rapid and superficial blowpipe work, with comparatively small flames constitutes an operation of minor importance. On the other hand, those who do lead-coating only use the lead en masse in the molten state for internal coating, or in small drops obtained from the melting of lead strips for external coating. But the blowpipe work is of long and continuous duration and the strong flame employed, particularly for internal coating, entails a considerable rise in the temperature of the lead surface. The greater danger that lead-coating involves must, in consequence, be accounted for by the volatilisation of the lead.

In lead-coating work the conditions for the volatilisation of lead differ from those which exist in lead foundries. In this connection the burning of tinned lead with a blowpipe produces in the neighbourhood of the flame, on the surface, and down to a certain depth in the lead layer, temperatures which come near to the temperatures of the hot oxyhydrogen or oxy-acetylene flame (2,400° or 3,000° C.); or at least equal to the melting point of lead (1,600° C.), at normal atmospheric pressure. The volatilisation of the lead is probably assisted by the draught caused by the flame which carries off the fumes as quickly as they are formed. In passing through the flame, or, at latest, at the moment of passing out of it, the lead fumes are changed, on making contact with the oxygen of the air, into lead oxide. This constitutes dust in a state of molecular dispersion in colloidal suspension in the air, e.g. lead fumes, and forms a very stable layer floating in the surrounding atmosphere. The volatilisation of the lead depends on the extent and the intensity of the flame which is used; nevertheless, temperature plays the chief role, so that one may say that different flames of varying temperatures under similar conditions determine volatilisation to a greater or less extent in proportion to the degree to which the temperature of the flame is raised. The least volatilisation is produced by the coal gas-compressed air flame; its extent progresses successively with the use of hydrogen-compressed air oxyhydrogen and oxy-acetylene flames.

According to the researches of Engel and Froboese, volatilisation is influenced by the chemical conditions of the flame; a reducing action, due to lack of oxygen and the presence of hydrocarbides, as in the lighting gas or acetylene flame which tends to less-
of the quantities of lead fumes given off during soldering, and, on the other hand, the medical examination of workers justifies the statement that danger from inhaling lead is considerable only in the immediate vicinity of the blowpipe flame, that is to say, at the working posts. The possibility of the accumulation in the air of workshops of lead fumes in a quantity sufficient to be dangerous to health need not be feared if the ventilation conditions are even approaching normal, since the quantity of lead that is volatilised as a rule is quite small.

The maximum danger exists during lead-coating operations, and particularly in internal coating. In this case, the danger is greater the larger the object to be lined, as oxyhydrogen and oxy-acetylene flames are used, and as the workers bend over or enter the interior of the casing or container which, in the case of repair work, may only possess a small outlet to the outer air. Under these conditions, accumulation of lead fumes is inevitable. This danger ceases to exist in cases of external lead-coating; besides, weaker flames are generally employed, particularly the hydrogen-compressed air or coal-gas-oxygen flames, and the heating of the lead does not reach such a high degree of intensity as that used for internal lead-coating. The danger is still less during lead soldering, which often involves the use of small pointed flames and requires accessory and preparatory work during which the blowpipe is not used.

Among accessory operations in lead-coating “burning off” causes important volatilisation of lead; this is due to the comparatively generally hydrogen-compressed air — for removing old lead coats; and to the high temperature, which may reach a considerable degree, especially when it is a question of melting a lead-coating covering two sides of an object or a piece of apparatus. The danger of the formation of lead fumes is, in this case, scarcely inferior to the danger in lead-coating, and it is only mitigated by the duration of the process, which is always short. The volatilisation of metallic lead during tinning, with an alloy containing 80 per cent lead, need scarcely be considered, as the danger is much less than with burning with pure lead.

Solder may contain as impurities, antimony, iron, copper, zinc, phosphorus or arsenic. This explains why solderers may be exposed to harmful effects brought by fumes from the metals in question or their compounds. In one large soldering factory, workers suffered from zinc fumes, with founder's ague.

Formerly, more frequently than at the present time, lead workers were threatened by the presence of arseniuretted hydrogen in the hydrogen used for the blowpipe and prepared in the factory itself from impure zinc and sulphuric acid. The use of hydrogen prepared by electrolytic means does away with this danger. Cases of poisoning from phosphuretted hydrogen were reported in Austria in 1920. During the war, the use of a “lead mercury” solder for the manufacture of batteries caused mercurial poisoning, which at times was quite serious.

The use of coal gas, of residual hydrogen containing carbon monoxide, or impure acetylene constitutes a danger of poisoning, if the piping is badly maintained. In fact, cases of carbon monoxide poisoning have been observed.

A fairly important source of danger is the work of repairing and fitting up apparatus employed in chemical industries, in which there are residues of toxic products. Poisoning has been observed among lead workers due to nitro- and amido-aromatic derivatives, and particularly to dinitrobenzines and dinitrochlorobenzines. It is especially workers employed at chemical works who are exposed to this type of poisoning.

The risk of lead poisoning among men employed in lead-accumulator factories corresponds pretty nearly to that of men who work at lead lining in the chemical industries. This danger appears to be more serious in British and German factories than in the United States, where the work is carried out on a belt conveyor, and by operations to a large extent automatic (A. Hamilton). The risk from lead fumes is, in this industry, greater in the work of lead-burning of cells than in the work of soldering battery plates, especially when the leading takes place after the lead-lining has been introduced into the battery case. In this instance the lead fumes which are given off are concentrated in the confined atmosphere which the worker must breathe when he puts his head into large cases or tanks (A. Hamilton and Wützdorff).

Lastly, a further danger is present in the dust caused by handling lead sheets coated with oxide.

Koelsch has observed corrosions of the buccal cavity and upper respiratory passages by fumes from the acid used for soldering.

See also article "Autogenous Welding".
At the time of the enquiry there were 5 workmen on the sick list, or 0.9 per cent, and the sickness statistics for 510 solderers showed, for a period covering two years, the following figures (in percentage): anaemia, 0.9; slight lead poisoning, 0.6; lead colic, 0.9; constipation and abdominal pains, 1.5.

Of the total, there were 2.9 per cent, of lead poisoning cases causing incapacity for work. The number of treated cases fit for work was far lower than this percentage.

At the time of the examination, 68, or 17.5 per cent., of the 388 skilled solderers, and 5, or 3.1 per cent., of the 161 assistants showed marked symptoms of lead poisoning, with positive results on blood tests, showing basophilic red corpuscles, and on urine tests, showing porphyrin. Of the trained solderers, 174, or 44.8 per cent., and 109, or 67.7 per cent., of the assistants were free from any objective symptoms, including the lead line.

Thus, there were 37.7 per cent, of doubtful cases among the skilled solderers, and 39.3 per cent, among the assistants.

The results found among the skilled solderers could be apportioned, according to the various types of work, as follows: lead-coating, positive 44 per cent., negative 17 per cent; lead-lining, positive 3, negative 94; tinning, positive 53, negative 13; manipulating lead in a cold state and transporting it, positive 0, negative 88.

The lead line existed among 30 per cent, of the skilled solderers, 64 per cent, among those employed on lead-coating; and 21 per cent., among those on lead-lining; with the lead soldering facies in 61 per cent, (lead-coating, 24; lead-lining, 0).

The blood pressure was very high, especially among the older men. The following are the figures (given as percentages):

<table>
<thead>
<tr>
<th>Age-groups</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 154 mm.</td>
<td></td>
</tr>
<tr>
<td>35.0</td>
<td>15.0</td>
</tr>
<tr>
<td>45.0</td>
<td>35.0</td>
</tr>
<tr>
<td>54.0</td>
<td>30.0</td>
</tr>
</tbody>
</table>

Thus the risk of lead-poisoning among lead solderers is relatively high, compared with this risk among other lead workers (Engel), although serious cases, either chronic or acute, and in particular paralysis, or lead colic, are not very frequent.

On the other hand, there are mild forms of poisoning which are characteristic of this category of workmen: anaemia, digestive troubles, and spastic constipation, which only occasionally leads on to colic. Circulatory disorders, and particularly hyper-tenions, are frequent, especially among the older men, among whom it is complicated with renal changes (saturine nephritis) and with arterio-sclerosis, localized especially in the cerebral blood vessels. The lead-lining extended, among the older men, the cerebral symptoms with lead amilobip, psychic troubles, and the symptoms of pseudo-uraemia which manifest themselves under the form...
of chronic saturnine encephalopathy with acute exacerbations. Hergt has described a case of chronic saturnine encephalopathy — a mental condition with initial visual troubles and a fatal termination through suicide — in which examination had failed to reveal arteriosclerotic changes. On the other hand, acute encephalopathy has not been found among lead solderers. The frequent occurrence of chronic saturnine encephalopathy, where the flame of the blowpipe is moved about rapidly with a back and forth motion over a fairly considerable surface. Even for work carried out at a work bench, as for lead-coating of piping, and for soldering lead in accumulator factories, the points which have to be soldered vary in position. On the other hand, a powerful exhaust with a large radius presents technical difficulties and causes inconvenience to the workers owing to draughts, so that for work of this kind it is only possible to employ movable exhaust hoods or cowls fixed at the end of elastic and flexible metal piping. In American accumulator factories, where the work is partly mechanical, the exhaust is carried down through a perforated plate which covers the benches of the men who lead the cells (A. Hamilton).

According to British medical inspectors, lead-poisoning among workmen engaged on leading sheet-iron by a process analogous to that of "tinning" in lead-covering, does not exist; but, on the contrary, it is particularly frequent among persons engaged in tinning hollow ware, where a special circumstances favour abundant volatilisation of lead chloride and the release of lead dust (Duckering). McBurney, of New York, in 1927 studied the health of 202 workers, 21 of whom were women, occupied on soldering work. Out of this total he found 30 cases of lung diseases, 18 of rheumatism, 1 of malaria, and 3 of various diseases. Examination of the blood disclosed the presence of basophilic granulations in 61 cases, anaemia in 57, and polychromatophilia in 47.

**HYGIENE**

In order to prevent lead poisoning, the requisite measures must be taken for suppressing the lead fumes which are given off during soldering, and so for avoiding their inhalation as far as possible. This is particularly important in lead-coating. The surrounding atmosphere cannot be kept satisfactorily pure, either by natural or artificial ventilation. Moreover, a dangerous concentration of lead fumes is only encountered, even in very crowded factories, at the work benches, and in the immediate vicinity of the blowpipes. In consequence, exhaust ventilation ought to be carried out locally wherever possible. However, effective working of such exhaust draughts is somewhat difficult of attainment, notably in the case of interior lead-coating, where the flame of the blowpipe is moved about rapidly with a back and forth motion over a fairly considerable surface. Even for work carried out at a work bench, as for lead-coating of piping, and for soldering lead in accumulator factories, the points which have to be soldered vary in position. On the other hand, a powerful exhaust with a large radius presents technical difficulties and causes inconvenience to the workers owing to draughts, so that for work of this kind it is only possible to employ movable exhaust hoods or cowls fixed at the end of elastic and flexible metal piping. In American accumulator factories, where the work is partly mechanical, the exhaust is carried down through a perforated plate which covers the benches of the men who lead the cells (A. Hamilton). When it is a question of interior lead-coating and of lead-lining cells of a definite size, effective movable exhaust is very seldom realisable. In these cases, and especially for the execution of repair work of short duration, such as the lead-covering of enclosed gear, the use of respirators is recommended. The most practical model is a mask supplied with fresh air through a tube.

It is a simple matter to organise a system of individual protection such as this, especially where compressed air is in use. In spite of their relative efficacy, respirators which have pads for absorbing colloidal lead fumes are less practical, on account of their prolonged use and the difficulty in maintaining them. In lead-lining, exhaust apparatus or masks may be dispensed with, especially when it is not a matter of interior working on tanks, or repair work performed at a work bench. Danger of lead poisoning during the removal of old lead from gear undergoing repair, or during the fitting of lead sheets may be avoided by the temporary use of filter masks.

In order to lessen the volatilisation of lead and the formation of lead fumes, the blowpipe flames should not be any larger, or their temperature any higher, than the technical process requires; moreover, the use of compressed air instead of oxygen or acetylene and gases containing hydrocarbons (Engel and Froboese) should assist in lessening the formation of fumes. But all these possibilities are rather narrowly limited from the technical point of view.

Generally speaking, lead-soldering shops ought to comply with all the hygienic requirements in force throughout every department where lead is worked; premises should be spacious and well ventilated and provided with
The lead risk, particularly in lead-lining work, from direct contact with the metal, or lead dust, which is quite a secondary danger as compared with inhalation, can easily be dealt with by installing lavatories where the workers can wash and have baths, rest-rooms and canteens. Special attention must also be paid to working clothes and to adequate cleaning of the shops, which should be undertaken with the object of preventing any accumulation and development of dust. These measures of cleanliness are particularly important, especially for solderers who come into contact with chemical products.

Medical examination on engagement, and periodical medical examination thereafter should be arranged at any rate for lead-coating factories, in order to detect in good time any slight symptoms of lead poisoning among the solderers. The possibility of transferring solderers who have been working at lead-coating to comparatively light work, such as lead-lining, tinning, transport and handling of cold lead should be considered, whenever they show any symptoms of lead poisoning.

Adequate instruction must be given to workers on the early symptoms of lead poisoning, as well as on the sources of danger and the means for avoiding them. Young men should only be employed as apprentices or assistants under medical guidance. Women should be excluded.

**LEGISLATION**

Measures for the protection of the health of solderers are in general to be found in regulations concerned with the prevention of lead poisoning, and, especially, in those relating to the equipment and working of electric accumulator factories. Thus, for instance, the German Regulations of 1888 lay down that soldering with a hydrogen or coal-gas blowpipe should, when the nature of the work permits it, only be carried out at fixed working places provided with effective exhaust. The elements used for the preparation of hydrogen, both the zinc and the sulphuric acid, must be technically pure, in order to prevent poisoning from arseniuretted hydrogen.

The instructions lay down adequate rules concerning the hygiene of the workplaces, their maintenance in a state of cleanliness, the installation of wash-basins and baths, and of canteens, the provision of working clothes, the organisation of periodical medical examination, and the prohibition of employment of women and children.

Compensation for lead poisoning among solderers who use lead solder or solder containing lead is granted in countries possessing a schedule according compensation for lead poisoning in accordance with the Anglo-Saxon formula (see article "Occupational Diseases: Definition and Compensation"), by France, Sweden, and the U.S.S.R. Sweden also grants compensation to solderers for injuries due to radiant heat and light.

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### Solvents

**French:** Dissolvants (Solvents). — **German:** Lösungsmittel. — **Italian:** Solventi. — **Spanish:** Disolventes.

Under the names of solvents or dis-solvents are included liquids used to suspend or dissolve different materials used in numerous operations of painting, lacquering, pasting, cleaning or in the extraction of fats and oils. Speaking generally, mixtures of different solvents are used in industry, mixtures which vary according to the technique of the process pursued.

The solvents most commonly used are: solvents with an alcohol base — amyl alcohol; butyl, whether synthetic or obtained during the making of acetone; ethyl, in the form of denatured alcohol; allyl, which is rarely used; and synthetic methyl alcohol. All these alcohols are generally used in the form of ethers.

It is interesting to note that to-day American industry prepares alcohols, superior to those usually found in laboratories, for volatile solvent purposes, especially in the varnish trade, to act as volatile solvents of acetate and nitrate of cellulose. As raw materials olefines are used or hydrocarbons not saturated with
gases and vapours, arising from "cracking" heavy petroleums, which are treated with sulphuric acid. Thus are obtained additional products whilst condensable saturated carbons remain unattacked. Hydrolysis of additional products, such as ethers and acids, ultimately enables alcohol and sulphuric acid to be obtained. When treatment is carried out at a sufficiently high temperature, ethylene also enters into the reaction, which makes it possible to obtain ethyl alcohol. The gases and fumes issuing from the "cracking" apparatus, are freed of their sulphurated compounds and then compressed. The greater part of the condensable products are thus liquefied. The secondary alcohols resulting from the hydrolysation are then separated by fractional distillation. The most abundant is isopropyl alcohol, which is colourless and has a pleasant smell; it is sold under the name of "petrolate".

In addition must be noted: 

Chlorethylalcohol beta (form.: C₂H₅ClO₂) (CH₂Cl₂H₂O₁), the importance of which from the industrial point of view has recently (1927) been shown. It is a clear colourless liquid analogous to glycerine, with an aromatic odour of alcohol, a density of 1.2 and a boiling point of 132° C. It splits up on boiling with water in any proportion; it splits up on boiling with water at 100° C. into glycol and acetaldehyde, and, when heated alone to 184° C., into crhoroethane and acetaldehyde. As an intermediary product in the manufacture of indigo, it has been made for twenty years in large quantities and sold commercially in the form of a solution of 40 or 100 per cent. of the pure product.

Acetone and its substitutes: the acetates of amyl, of ethyl, of butyl, adronal, acetal, ethylacetone, methylacetone, propylacetone, and cyclohexanol; and also formic acid and amyl formiate.

Benzene and its homologues; their nitro- and chloro-compounds; solvent naphtha; the phenols; sulphide of carbon; tetra-chloride of carbon, which enters into a product known under the name of "Dermatine" or "Dermantine".

Petrol benzine, either heavy or light, which is less used; the ethers of alcohols of the aliphatic series; acetic, ethyllic, and formic ethers, with, eventually, the addition of lactic ether.

The fatty series of the chloro-hydrocarbons. Dating from 1908, chloro compounds, colourless liquids, prepared by making chlorine act on acetylene, were put on the market as "uninflammable solvents"; they do not form explosive mixtures with air, and do not attack the metal parts of apparatus; further they only suffer a minimum loss in operation, from 0.14 per cent. They are: dichloroethylene or diene, a solvent of india-rubber; trichlorethylene or trine, a solvent of fats, paraffin and vaseline; tetra-chlorethylene or etilene, a good agent for degreasing materials; tetrachlorethane or tetrane; pentachlorethane or pentaline; and hexachlorethane; chloroform; sangujol, a mixture of limited hydrocarbons, naphthene and benzene; white spirit; pine oils and residues from manufacture; heavy and light oils of camphor; oil of turpentine.

As a substitute for this last, para-cymene (1 methyl-4 isopropylbenzene) may with advantage be used to replace toluene, especially in the preparation of varnishes with a basis of cellulose ethers; it is a by-product, up till now generally lost, in the manufacture of sulphite of wood pulp.

Uses

All these solvents, either alone, or more often mixed, are used in making volatile lacquers, generally with various resinous bases; or in making lacquers with an oil base, which formerly were prepared by means of such drying oils as linseed, white wood, hemp and turpentine; or colours and varnishes to be applied by brush or spray; or Zapon lacquers, which are solutions of nitro-cellulose, camphorated pyroxyline, celluloid, or cellon, in suitable solvents, used for coating metal articles, aeroplane wings, and balloons; or anti-rust products with a base of asphalt, or pitch, dissolved preferably in benzene or phenol; or impregnating and adhesive materials; or solutions of india-rubber, resins, or celluloid; or preparing various adhesives in certain solvents. They are often known under the name of "cements" in the manufacture of rubber, oil cloth, or such clothing as boots and hats; for material for balloons and aeroplanes; of brushes; of accumulators; and of celluloid articles.

The necessity for thoroughly removing all traces of tar which are found on fleeces, especially those coming from Australia, has led manufacturers to replace the mechanical method, of pulling out the stained fibres with pincers, by a chemical method. A considerable number of products known under fancy names and generally of secret composition, have of recent years been put on the market. The wool is steeped in a more or less concentrated bath of solvent, or the stained part is treated by allowing the solvent to flow from a burette, as in the case of a sewing machine is oiled. These products, which during the last two or three years have caused much damage, are known under such names as "Tetralin", "Perpentol S", "Lanadin Lap" and "Poko". These solvents of which usually have a basis of trichloroethylene, chloride of ethylene (see article "Ethylene"), or chloro-hydrocarbons.
Solvents are further used for the extraction of fats from bones, waste meat and fish, and of oils from oleaginous grain and from oil cake made from oleaginous grain; for chemical washing and for cleaning and degreasing such metal articles as printing type and ink rolls, for which purpose derivatives of benzene and its homologues are used by preference, and the chloro-hydrocarbons of the fatty series.

From a practical point of view it seems important to point out that these solvents are put on the market under fancy names, so that it is very often impossible to know what product has been used as the solvent.


**Sources of Dangers**

(a) During the manufacture of solvents or products which contain them, the risk is comparatively slight, as the technical processes are generally carried out in apparatus either closed or under reduced pressure.

(b) During use, the volatilisation of solvents constitutes, on the other hand, the principal source of risk. There may be mentioned in the painting industry, the preparation of baths, and the lacquering processes, varnishing by dipping, and the use of the spray which is coming to replace brush work more and more. Fumes are given off from the baths, often at the ordinary temperature, and of course more powerfully at the temperatures employed in technical processes or under special conditions in a confined space. In painting with a spray, danger is caused by the cloud from the vaporising jet, which projects small extremely fine liquid particles in suspension into the air (see article "Painting").

The use of glues, cements, and products used for cleaning and for the extraction of fats, also exposes workmen to the action of poisonous fumes from solvents. There may be mentioned the serious injuries caused by using cements made with benzol in the manufacture of waterproof goods (see article "Benzene"); by using tar solvents in making woollen hats; and in making straw hats (see article "Straw").

**Toxic Effect**

It is only during the last few years that precise facts relating to the toxic properties of solvents have been available. This lack of accurate knowledge is explained by the common use of fancy trade names; by keeping secret the composition of the products used; by variations in composition of the same commercial product, either through change of appearance or of smell, or sometimes by variations in the toxic effect; by the use of constituents which are not always pure; or by the addition of accessory products, such as nitro-benzene, for instance, to impart a scent.

Generally speaking the toxic effect of solvents may be outlined as follows:

(1) The solvent, on reaching the blood stream, acts on the fats and lipoids of the body for which it shows a great affinity; in this way it disturbs the chemistry of the cells, for it removes the integrating substances analogous to the lecithins. This fact explains why the resulting organic lesions are more serious in tissues and organs which are the richest in fats and lecithins, and why solvents particularly exert a selective influence upon the central nervous system.

The toxic effect of solvents depends on the "coefficient of separation" which controls their separation in a mixture of water and substances analogous to fats; that is to say their toxic action is greater as their power of solubility in fats is greater, and less as their solubility in water is greater.

There is generally a close connection between the gravity of the damage and the changes in the nerve cells. This connection, however, for certain poisons, such as ether, chloroform, and alcohol, is not so direct; for the lesions are not permanent and "restitutio in integrum" may take place. In the
case of such other poisons as anhydrides and halogen derivatives, on the other hand, damage only occurs after a certain period and is from the first incurable owing to the formation of stable intra-cellular combinations.

Judging from experiments on animals, from the point of view of industrial hygiene there may be considered as being under suspicion all those solvents of which the fumes, while not causing narcosis, in comparatively weak concentrations such as 1 to 10 mg. per litre of air inhaled for one to three hours, induce after a "latent period" of apparent health, a progressive morbid condition of a narcotic type, and cause, owing to the process of the intoxication being irreversible, serious or fatal cases of poisoning (Bruckner).

Between these two types of solvents, one of which causes reversible and the other irreversible reactions, there exist whole series of intermediary solvents, concerning which toxicity can only be estimated by physiological tests permitting of the elimination of the most dangerous of them.

(2) Some solvents have a specific action on particular organs; thus the chloro-hydrocarbons of the fatty series act on the liver; carbon bisulphide acts on the central and peripheral nervous system; and methyl alcohol on the optic nerve.

The toxic action of tetracaine has been carefully studied in Germany by experts. They have found that it is scarcely toxic at all and that in animals it only causes nephritis after an administration of long duration. Similarly in tetracaine works and in factories where woollen hats are made and this chemical is used, in addition to trouble arising from the smell, only slight disturbances have been reported, such as headaches, vertigo, and localised pains in the kidney region. The urine may be brown or black, but this coloration is not consistent. But, if the tetracaine is in concentrated solution, it causes dermatitis with eczema and rhagades, and also nephritis, betrayed by the presence in the urine of hyaline casts, with epithelium from the upper urinary passages and blood. Analysis detects a product analogous to phenol.

What is of practical interest is the fact, emphasised by Gerbis, that this product which has a high boiling point, about 203°C., is easily conveyed by steam. This fact easily explains the serious injuries caused by the inhalation of Perpentol S, and of other products of tetracaine base, containing a very powerful odour, merely set up a feeling of malaise induced by the

Perpentol S, when taken separately, are scarcely toxic at all; but the complex product exerts a pronounced influence on the blood, the nervous system and kidneys. For this reason experts are searching for a product with a less toxic composition, but which offers the technical advantages of Perpentol S.

Special mention should be made here of chloroethylalcohol beta, which is a poison to the nervous system and more particularly to metabolism. Up to the present chloroethylalcohol has been regarded by German investigations, made by Koelsch (I. G. Fabrikenwerk, Ludwigshafen) as recently as 1927, in consequence of toxic effects which occurred in course of use, it has a high degree of toxicity. This fact has been proved by inhalation of its vapours and absorption through the skin in such animals as cats, guinea-pigs and rabbits, which died the same day or after a few days, according to the concentration used — from 0.002 mg. to 0.004 mg. per litre of air. The symptoms appear a definite time after exposure to the poison with vomiting, disturbances of the pupillary and defensive reactions, disorders of gait, and death which occurs from respiratory paralysis. Autopsies revealed localised irritation in the recesses of the respiratory passages, with fatty degeneration of the heart, liver, kidneys, and definite diminution in weight, showing disorders of metabolism. The experiments made at Ludwigshafen confirm those of Koelsch, and show that exposure to the poison, in more or less concentrated doses — from a minimum poisonous dose of 3.6 mg. per litre of air — has caused death, or, in its absence, such nervous disturbances and serious interferences with the metabolism that convalescence lasts weeks and months.

Finally, reference should be made to the specific irritating, suffocating action exerted by some solvents on the mucous membrane of the respiratory passages, with a repercussion on the heart and blood vessels; according to Brückner it is probably due to an irreversible reaction. But sometimes it is only a question of non-poisonous fumes, which merely exert an irritating effect on the mucous membranes of the eyes and upper respiratory passages.

Certain products produce an injurious effect on the skin by removing the fatty layer; reducers, which possess a very powerful odour, merely set up a feeling of malaise induced by the
SOLVENTS

nauseating effect caused by their disagreeable smell. A distinct smell pervading the atmosphere of a workshop is caused by 0.001 grm. of ethylic ether per cubic metre; by 0.09 grm. of acetate of amyl; or by 0.6 grm. of methyl alcohol.

The period of exposure plays an important part. The fumes of some solvents, even of those most commonly used, may, as a matter of fact, be dangerous when they are breathed for a short time in a highly concentrated form, and may then cause death by acute poisoning; while others, on the contrary, e.g. benzene, cause death by chronic poisoning, when they are breathed for a long period in low concentrations.

Individual susceptibility, of which clinical work has shown the great importance, must also be taken into account, the symptoms of poisoning varying for an equal exposure, according to the individual. Apart from idiosyncrasy, a predisposing part is played by states of depression, nervous affections, cachexia, cardiac lesions, such vascular trouble as arteriosclerosis, or such pulmonary conditions as emphysema, or disorders of the liver. Thus in fatal cases of poisoning by chloro-ethylalcohol beta autopsy on the victims has revealed the previous existence of more or less extensive organic lesions.

External conditions must also be taken into account. Thus temperature of the workplaces, increased temperature augments the volatility of the products, as does also the existence of large evaporating surfaces; technical processes may affect the mode of action of the poison, and the degree of poisoning; while the ventilation of the work-places is of course important.

SOLVENTS

Solvents may act either in the form of fumes — the most common form — or in the form of vapour, as when paint is applied by spraying.

The principal path of entry is by the respiratory passages, due to the inhalation of vapour or mist, which enables the poison to penetrate into the blood stream and, through its agency, into the general system.

But resorption by the skin plays a part which is far from negligible, for these solvents destroy the protecting fatty layer of the skin and diminish its suppleness.

STATISTICS

It is extremely difficult to get accurate statistics as to cases of poisoning by various solvents, in consequence of the multiplicity of the products used, of the uncertainty in their exact composition and of the numerous industries and operations in which they are employed. (See the articles referring to various products mentioned in the article on “Ethylene.”)

It is interesting to notice here the statistics reported by Koelsch on chloro-ethylalcohol beta in Germany.

No case has been reported during the manufacture of this product. All have been connected with its use: 3 cases, of which 2 were fatal, occurred in a paper works in 1923, while cleaning the cylinders of a machine with rags soaked in this liquid; 4 other cases, of which one was fatal, happened in 1925, in a linoleum factory, during the use of a quick drying coloured paste with a basis of chloroethylalcohol; 2 other cases appear to have occurred since elsewhere.

In 1925, 15 cases of poisoning by Perpentol S were reported from a woollen hat factory in Prussia.

PATHOLOGY

The pathology of the various solvents is almost identical; just indeed as is their general physiological action.

Solvents act first and foremost on the central nervous system, causing a state resembling drunkenness, with headache, somnolence, vertigo and staggering gait, loss of will power and of memory, clouding of the senses, hallucinations, precordial pains, insomnia, disordered vision, malaise and feebleness which may pass on to loss of consciousness. Sometimes acute mental disorders are observed, due chiefly to preparations of benzene and its homologues, and chloro-hydrocarbons of the fatty series. Fairly serious gastro-intestinal disorders have also been noted, with nausea, vomiting, diarrhoea and jaundice. In acute poisonings, caused by concentrated exposure to such toxic products as chloro-hydrocarbons, death may occur from respiratory paralysis, syncope and asphyxia. Except for concentrated exposures with rapidly fatal results, recovery is generally quick if the patient is moved at once to the open air. Nevertheless, cases fairly long in onset with fairly serious sequelae have been noted. Koelsch remarks upon the opposition shown by working women to giving up their work or changing their occupations.

The most varied clinical pictures may appear, depending on the quantity, the nature and impurities of the substances used.

The symptomatology takes on special aspects as the products exercise specific actions. Fatty degeneration of the liver results from chloro-hydrocarbons;
nervous disorders of central or peripheral origin from sulhide of carbon; incurable lesions of the optic nerve from methyl alcohol; renal symptoms from tetraline, with renal pains, black and pigmented urine having a special odour and containing casts and renal crystals.

Poisoning by chloroethylalcohol beta which rarely begins at the moment when the poison is absorbed, but generally some time after the termination of work, is characterised by localised lesions on the superficial mucous membranes and the deep respiratory passages. According to reported cases, the clinical picture presents the following type:

In an acute, rapid case of fatal poisoning which occurred during work, the onset was ushered in by a state of malaise, nausea and vomiting. The patient, after he had returned home, was taken with headache, slight mental confusion, and bilious vomiting, without fever or symptoms connected with the heart or respiratory apparatus. Sudden death occurred the next morning after a fainting attack. In another victim, the onset was also during work, with somnolence causing interruption of work, followed in the afternoon by dyspnoea. Death occurred in the evening from pulmonary and cerebral oedema. In subacute poisonings there is a varying period after the cessation of work, in the form of vomiting, vertigo, headache and weakness. In some cases, workers were able to return to work the next day; in others, recovery took place without sequelae, but after a long convalescence. Slight poisoning shows itself simply by local manifestations, with sensations of tingling and of burning at the eyes.

Products, such as tetraline and Perpentol S, used to clean tar marks from wool, have been the cause of stupor, insomnia and disturbed sleep; and in serious cases of nephritis and convulsions.

These solvents cause local lesions on the superficial mucous membranes of the conjunctiva and upper respiratory passages, especially in the case of aldehyde or ketones used as such, or found as impurities in the products employed.

They act also on the skin, provoking eczema, oedema, inflammatory reactions and rhabdoses, due either to the action of the poisons themselves or to intense defatting of the skin, which facilitates the entrance of bacteria and their attack on the sudoriparous glands.

Hygiene

The protective measures to be taken involve on the one hand the construction and arrangement of the workplaces, and on the other hand the use of the solvents.

Necessary measures should be taken to protect stores where solvents are kept against any risk of fire or explosion, as well as to make sure that the workers employed in this department of the factory are protected against all danger from the inhalation of poisonous vapours.

Dangerous processes should be carried on in places separated as much as possible from the other departments of the factory.

The receptacles used should only be of the hermetically sealed pattern. Rags soaked in solvents should be placed in closed boxes. Any liquid upset on the ground should be at once cleaned up and removed.

The escape of fumes and vapours should be prevented by adequate technical measures, such as exhaust ventilation and better regulation of spraying jets; where these measures are not possible, the fumes or vapours must be so diluted that their absorption, even if continued, cannot cause injury to the persons exposed. There is then need for the installation of a general system of ventilation or an adequate localised one.

All processes which generate vapours or steam should be carried on in spacious workplaces which are well ventilated. The actual processes should be carried on in hermetically sealed apparatus, or, in default of that, in apparatus covered in as much as possible and provided with some efficient system of local exhaust. Sometimes for that purpose, the natural draught of high chimneys is used, or jets of water or of steam; usually powerful aspiration is used, the mouths of the suction ducts being placed as close as possible to the source of the fumes.

The choice of apparatus to be used, its size, and the extent of the aspirating area depend on various factors, such as the rate of evaporation of the solvents used; the degree of their toxicity; variations in their concentrations in the air, according to the work, draughts and atmospheric conditions; the nature and density of the fumes which may be heavier or lighter than air; and the special technique to be observed.

Attention should be given to the entrance of air and to its heating, especially in winter, with a view to prevent-
When liquids with a basis of solvents are applied in confined spaces, such as tanks and boilers, or more especially when spray-guns are used, general measures of protection should be augmented by the use of protective appliances for each individual, such as respiratory masks, helmets, and goggles; but it must not be forgotten that such appliances are not willingly worn by workers and are only indicated for short periods of work. The production and accumulation of static electricity must be avoided by earthing the apparatus. (See articles "Benzene" and "Dust, Fumes and Smoke".)

Workmen should be prohibited from entering tanks or tubes which have held solvents, before such places have been carefully cleaned and completely freed of all fumes.

Absorption by the skin should be combated by providing for all requisite measures of personal cleanliness with baths, douches, and lavatories, so that personal factors tending to dermatitis may be eliminated. Lubricating the hands before and after work with lanoline or wool grease prevents eczema; this precaution renders useless the wearing of protecting gloves, which may, indeed, be dangerous and constitute a source of injury. It is, therefore, desirable that employers should arrange for this lubrication and supply the worker with the material required.

Improvement of the hygienic conditions in industries using solvents still raises numerous difficulties: there is the need for ascertaining the exact composition of the products used; disadvantages arise from present-day methods of work, and the manner in which the technique may regulate them; and problems of preventing injuries to the health of workers still await solution.

Workers should receive instruction by different methods — by lectures, leaflets, posters, and notices — as to the poisonous nature of the products they manipulate and the dangers they incur.

It is for this reason, that as regards chloroethylalcohol beta, some German factories have decided to restrict the sale to special and well-defined cases, while drawing in a special manner the attention of users either to the poisonous nature of the product, or to the precautionary measures to be taken. All these precautions should be effectively completed by medical examination on commencing work and periodically thereafter, enabling a choice of personnel to be made in accordance with constitution and physiology, and permitting of the exclusion of delicate subjects, as well as regular alternation of occupation for those exposed.
Soot


Soot is the product of incomplete combustion of the organic carbonated compounds produced by a smoky flame (coals, tars, mineral oils, resins, etc.).

In its natural state it settles throughout chimneys and hearths in the form of a blackish substance forming brownish, brilliant, fragile crusts or scale with an empyreumatic odour and a bitter taste, soluble in water which takes on a yellowish colouration. Soot contains carbon, empyreumatic substances, creosote, salts of ammonium and other special products, notably a yellow bitter oleaginous substance to which vermicide properties are attributed.

The formation of soot is dependent, on the one hand, on the properties of the combustion materials, and, on the other, on the type of construction of and manner of feeding the furnaces. Poor coals giving hardly any smoke produce very little soot. Faulty construction and badly disposed apertures in hearths, as well as defective charging (lack of air supply), which prevent complete combustion, favour the production of soot.

Soot is generally manufactured by the incomplete combustion of tar and tar oils which are caused to fall on to the hearth and burnt there with the smallest quantity of air possible. Cooled gases laden with particles of carbon are directed into precipitation chambers containing baffle plates or cloth screens on which the soot settles. The soot recovered is then sifted, washed with sulphuric acid or potash, dried and packed in barrels. The soot or "black" is finer the further the point at which it is collected is removed from the place of combustion.

According to the produce used there may be distinguished: oil soot, resin soot, lamp black, a very fine variety obtained by combustion of liquid or gaseous products in special lamps. Acetylene likewise gives a very black soot. In America soot is produced by burning directly petrol gas.

Soot is of course occasionally utilised as artificial manure. Manufactured soot (lamp black), unaffected by light or by ordinary chemical reagents and insoluble in all solvents, is used as a pigment in oil paints, varnishes, Chinese ink, printing ink, and in the preparation of certain pigments (bistre, for instance, etc.).

Sources of Risk

Sources of risk consist of exposure to soot dust and other irritant substances which it may contain (tars, phenols, creosotes, etc.), and which depend, as far as natural soot is concerned, principally on the kind of coal from which it originates: coals rich in sulphur or containing traces of arsenic to which an irritant effect is ascribed (see article "Tumours of Occupational Origin"). Besides soot, an important part is played by coal dust and perspiration, which exert harmful action on the lipoid substances of the skin, causing mitotic cellular subdivision (Koelsch). Chimneysweeps, blacksmiths, furnace and machine stokers, cleaners of hearths and furnaces, and less usually agricultural workers, gardeners, etc., may be enumerated amongst the occupational categories exposed to injuries connected with soot.

As regards chimneysweeps, it is essential to add as additional sources of injury exposure to inclemency of the weather, strain due to excessive effort, especially with the knees and elbows, and also the risk of accidents. Amongst workers engaged in the production of artificial soot, it is accordingly those who collect and pack it in barrels who are most exposed to risk.

Statistics

Available statistics are chiefly of English origin. According to the figures published by the Registrar-General for the
period 1921-1923 the mortality rate for chimneysweeps is above the average and the principal causes of death are cancer, phthisis, circulatory diseases and cirrhosis of the liver. The mortality rate for skin cancer, especially of the scrotum, is 11½ times that of the average.

This high cancer mortality rate already led English authorities to devote their attention to the subject, and from the end of last century such medical experts as Butlin, Ogle and Tatham have published figures to be found in British medical literature.

Investigations made in Europe (Austria, France and Germany) and in the United States have indicated that cancer is a very rare occurrence amongst chimneysweeps in these different countries, a fact which is attributed on the one hand to the varying nature of the soot dependant on the types of coal employed — and on the construction of the furnace chimneys used 1, and on the other hand to the habits of the chimneysweeps (wearing of working clothes, personal cleanliness). Richter considers that chimneysweeps' cancer has completely disappeared in Germany, and he attributes this to improved hygienic methods observed.

PATHOLOGY

The injuries encountered are chiefly connected with the action of soot dust, which has been thoroughly studied by Ascher in Germany, W. C. White in the United States, as well as by numerous committees engaged in the smoke abatement campaign.

Weyl considers that, despite the fact that chimneysweeps are of necessity exposed to the inclemency of the weather, especially as they work throughout the cold season, their occupation is nevertheless a relatively healthy one. According to Oliver, chimneysweeps suffer more than the average worker from acute respiratory affections: forms of rhino-pharyngitis and adenoids, forms of laryngitis, bronchial catarrh, inflammation of the lungs, pleurisy, etc., and especially tuberculosi. An enquiry conducted in 1927 by Hedborg amongst chimney-sweeps in Stockholm has shown that amongst 124 workers examined, or three-quarters of the total number, with an average length of employment of twenty-two years, there occurred 14 cases of pulmonary tuberculosis (3 active and 11 latent). This authority has found that while tuberculosis is of frequent occurrence, it shows a remarkable tendency to heal up or remain stationary, with the result that it is hardly possible in this connection to speak of the nefarious influence exerted by the occupation.

According to Schmidt, tuberculosis accounts for 60 per cent. of all cases of sickness, and 42 per cent. of all fatal cases occurring amongst German chimneysweeps.

On autopsy the lungs show blackish pigmentation due to particles of soot. Sternberg reports that stokers and chimneysweeps show this pigmentation, which is not accompanied by fibrosis. In his experiments on an animal, Arnold distinguished three kinds of pulmonary lesions due to the inhalation of soot: simple anthracosis, anthracotic melanosis of the lungs, and indurated anthracosis ("anthracosis simplex", "melanosis anthracotica pulmonum", and "anthracosis indurativa"), the latter only occurring as a result of the combined action of silica dust. Claisse and Josué, Lebenu, and Willis have never been able to produce fibrosis amongst animals by simple inhalation of soot.

It must be noted, on the other hand, that Cooke reported in 1930 a case of pneumoconiosis confirmed by post-mortem examination, as affecting a worker of thirty-five years of age who had been employed during the nine and a half years preceding death as a boiler and chimney cleaner.

Diseases of the heart and urinary system have been reported by Oliver; on the other hand, diseases of the digestive passage seem to be a rare occurrence.

There have likewise been reported chronic affections of the eyes (conjunctivitis) and of the middle ear (catarrh) due to the irritant action of soot dust, and, in the case of the eyes, also to the action of foreign bodies. Eczematous inflammation of the eyelids occurs likewise not infrequently amongst workers handling soot.

J. W. Thomas in 1930 met with a case of epithelial hyperplasia of the cornea affecting a furnace stoker aged fifty-two years, and found to be due to the penetration of dust from the combustible, which had set up persistent irritation even after a lapse of three years. In 1927 three small white masses were clearly visible on the one on the cornea, another on the internal limbus, and a third on the conjunctiva of the eyeball. Later on the conjunctival mass disappeared and two others coalesced to form a corneal mass, which developed finally into the formation of an excrescence for which excision was necessary (1930). The author considers that dust from the combustible, which contained 6 per...
cent. of pitch, had played a definite etiological part in the production of the tumour. Sixteen years earlier this worker had suffered from a wart on the face due to the action of pitch, and which had to be removed.

Lesions of the skin are the most frequent and are of greater importance. Under the action of soot the skin becomes thickened, hard and dry. Eczema affects the hands, legs and feet of those engaged in packing soot in barrels (Rambozsek).

Pichler in 1930 described a case of pigmentation of the skin affecting a chimney-sweep. Pigmentation is frequently situated on the hands and feet (ten times out of twenty), with linear scars, and small blue wounds with a blackish halo.

Cutaneous lesions do not often remain stationary at the stage of pigmentation or eczema, but undergo a malignant transformation causing Bowen's disease, dermatitis and true epithelioma, especially in the case of chimney-sweeps.

Chimneysweeps' cancer was described for the first time by Percival Pott in 1775 and studied, according to him, by numerous English authorities. On the basis of clinical observation, Pott distinguished cancer of the scrotum in English chimney-sweeps from a number of affections at that time designated under the name of cancer, and definitely ascribed its origin to soot — this being also later the opinion of Virchow — specifying clearly that the disease had its origin in the accumulation of soot in the folds of the scrotum. Spencer (1890) claimed to be able to demonstrate the presence of particles of soot in the cancer cells of chimney-sweeps.

Warts due to soot ("fuliginous warts") have been described in France by Selle (1787) and Alibert (1817); cases of cancer in Germany by Stöhr (Thesis of 1820: he refers to cases studied by Major and Michon); and by R. Köhler (1853); in Switzerland at the beginning of the nineteenth century by Jurine, of Geneva. Futterer collected 47 cases of chimney-sweeps' cancer, described in English and American literature in the period 1808 to 1854.

Chimneysweeps' cancer is generally situated on the external genital organs, most frequently on the lower part of the scrotum, and may rarely on the penis. In this case it chiefly affects the skin, whilst the gland and the prepuce do not seem to be affected except indirectly.

The outbreak occurs after a certain period of exposure to the action of soot, generally twenty to twenty-five years. There have been cited in this connection as quite exceptional lengths of employment periods of one to two years. Cancer preferably attacks subjects between forty and sixty years of age, though medical literature contains a reference to cases amongst younger individuals: 16 to 22 years (Stöhr); 15 years (Wadd); 8 years (Earle — at the time when "chimney boys" were employed in Great Britain as chimney-sweeps).

The disease may even break out after all cessation of contact with soot. Medical literature contains particulars of an instance in which workers who had left the occupation of chimney-sweep were affected after a lapse of twenty years.

The skin becomes dry, rough and pigmented, and later is covered with papilloma, which constitute a pre-cancerous stage. These papilloma may exist for years without suffering malignant transformation, and may grow in length, becoming horny and forming "skin corns," or they may remain quite small and even disappear, but in general they develop into a form of cancer, which, from the histological point of view, is a type of spinocellular carcinoma.

At the moment of malignant transformation the papilloma proliferate, become more salient, take deeper root and ulcerate in the centre (Butlin). In the absence of intervention the ulceration spreads, the edges become swollen and hardened, exuberant scirrhous formations grow on the surface, whilst fettid and highly irritant matter is discharged from the tumour (Earle). This stage is characterised by intense pruritus, which yields later to pain (Cooper). The patients become cachectic, lose weight, and die slowly or suddenly as the result of some intercurrent complication (Curling).

This form of cancer in its evolution may spread to the testicles, the spermatic cord, the inguinal glands, the abdomen and the intra-abdominal organs (Pott). Yet these forms of metastasis of relatively rare occurrence may nevertheless break out or continue their growth subsequent to ex- tirpation of the primary tumour.

More rarely cancer breaks out in the inguinal glands without the existence of scrotal tumour (Paget, Lawson).

The situation is therefore typical, though the disease may also be located on other parts of the body (face, hands, etc.). Whilst this form of cancer has been met with fairly frequently amongst members of chimney-sweeps' families, it may also occur in several occupations in which the handling of soot is involved.
Curling (1845) described a case of cancer of the hand affecting a gardener who strewed soot on plants for the destruction of parasites. Lawrence (1850) refers to a case of cancer of the tegmen tympani, and Cooper to a case of cancer of the cheek amongst workers engaged in carrying sacks of soot on their shoulders. Cusack removed a dangerous growth from the hand of a woman who had worked amongst soot. Curling has also described cases of papilloma on the toes amongst workers who packed soot in barrels barefooted.

Paget has likewise reported a case of cancer of the larynx affecting a chimney sweep, and was led to enquire whether this was purely a coincidence, or, on the other hand, whether there was a possibility that the soot inhaled had caused injury of the organ in question. Manouvrier (1876) has reported the occurrence amongst blast-furnace stokers of cancerous formations not only on the nose but also on the hands and face. In 1930 Bedford studied a case of multiple carcinoma affecting a smith aged forty-five and with a working experience of twenty years' duration. This worker, after the removal of a tumour from the lower lip, suffered from a further tumour on the scrotum subsequent to an eczematous condition which had lasted several months.

Early excision of the tissues affected does not protect the individuals in question from recurrences, which, however, do not appear in the cicatricial tissue but beside it, or at another point. These recurrences occur even when the patient has never been in contact with soot after the first attack. Curling cites the case of a chimney sweep who during a period of twenty-two years had been operated on five times and suffered from metastases of the inguinal glands. He likewise met with a case of a chimney sweep aged sixty-six who had had his finger amputated for cancer and who suffered from a cancerous papilloma on the other hand. He had previously been operated on for scrotal cancer thirty-five years earlier.

Besides the carcinogenic action of soot, mention should also be made of the predisposing effect of local irritation, and this explains certain occurrences at the point at which there is irritation of the skin: inguinal cancer at points of irritation due to wearing of an appliance for hernia (Rosser, 1886).

HYGIENE

Factories for the production of lamp black from distillation of coal, tar and bitumens in certain countries come within the list of scheduled establishments classified as dangerous or offensive trades, and are on this account committed to the observance of a certain number of measures concerning principally safety (construction of factories far from inhabited centres; construction in incombustible material with iron doors; separation of furnaces and boilers from lamp black rooms, and the application to boilers of all necessary devices for preventing liberation of disagreeable odours and harmful gases; the provision of high chimneys provided with metal trellis work; in the case of factories using resins and tars, compulsory mixing of the raw materials in boilers placed under hoods; construction of hearths separate from workrooms, etc.). These measures should be supplemented by measures of general hygiene and by those adequate for preventing raising of dust and smoke production (effective with withdrawal of these), especially during the extraction of lamp black from precipitation chambers. Precautionary measures against fire are likewise necessary; e.g. prohibition of access to certain workrooms with naked lights. Application of requisite measures for preventing all liberation of dust during bagging or barrelling of the soot is also necessary. Automatic apparatus provided with exhaust devices and means of recuperation should be adopted where possible, though such measures are at times not of ready application on account of the very fine state of subdivision of the soot.

During chimney sweeping, efforts should be made to diminish as far as possible or entirely eliminate all contact with soot. In Great Britain a recent reduction in the number of cases of chimney sweeps' cancer is attributed to the use of the "long brush", which involves less contact with the soot. Other types of apparatus for chimney sweeping and of withdrawal by exhaust adopted for various kinds of chimneys and boilers at the present time render the operations in question semi- or even entirely automatic.

These measures should be completed by measures of personal hygiene: wearing of working clothes, gloves, glasses and masks for protection against dust, but chiefly measures of cleanliness: provision of washing facilities, douche baths, etc.

As regards prophylaxis, periodical medical examination of workers coming in contact with soot is of primary importance. Abandoning the occupation in question may render the adult chimney sweep less subject to cancer,
but in no wise guarantees him against recurrence of this condition.

**Legislation**

Compulsory notification of cancer of the skin and cancerous tumours due to soot is provided for under French, Dutch and Polish legislation.

In Germany forms of chronic recurring dermatitis due to the action of soot entitle the worker to compensation in Great Britain and in Western Australia compensation is granted for cancer of the scrotum occurring amongst chimney sweeps; in Austria cancer of the skin due to soot; in the U.S.S.R. cancer of the skin. Compensation may also be claimed in the case of dermatitis or diseases due to dust, especially where chronic inflammation of the skin is concerned (U.S.S.R.), as well as injuries (ulcers) of the cornea due to the use of pitch, tar, bitumen, mineral oil, or "a compound, product or residue of one of these substances" (Great Britain).

**Bibliography**


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**Sport (Hygiene and Physio-Pathology of)**

There is no divergence of opinion as to the great benefit derived from physical exercise, from the twofold point of view of the general mobilisation of the body and of the mental recreation it affords to those who do physical work.

Too often workers have to endure immobility or restricted mobilisation, unnatural postures from which may even result physical deformity or organic deterioration. Quite apart from various occupational deformations of the thorax or of the vertebral column, prolonged standing in itself causes in time circulatory disorders and a relative anaemia, due to stasis of blood in the legs and consequently diminution of blood in the rest of the body (Atzler and Herbili).

All these troubles and ill-effects are corrected by physical exercise. Its beneficial influence on the body is manifested by physical and physiological modifications, observed by many experts before and after the practice of sports. Thus, for instance, among physical modifications, Kaup and Grosse found that during training the person occupied in sport loses weight, but, on the other hand, he develops greater respiratory amplitude, greater vital capacity, an increase in chest measurement and in the circumference of the arms when outstretched, but especially when flexed, and also of the thighs.

As regards physiological modifications, during the rest before the exercise, they report, between the values taken at the beginning and the values taken during the training, a diminution in respiratory volume and the work of the heart. The difference between these values increased in a marked way when it was a question of a performance amounting to 320 kilogrammes per minute.

Under the influence of many and varied physical exercises, combined with adequate feeding, there occurs an increase in weight which has been attributed to an increase in muscular volume (Hersheimer). This development is more clearly demonstrated in the case of untrained youths, of slender build and of subnormal weight. This muscular hypertrophy is accompanied by an increase in muscular power; and it has been observed that this latter, after a training of twelve weeks, increased by 1,143 per cent. (Palmen).

Physical exercises may be classified as exercises for increasing the general strength of the local strength or skill (F. A. Schmidt). The first include heavy athletics; the second movements are limited to a restricted number of muscles, as in gymnastic exercises, boating or swimming; the last include exercise with the lance, quoits, and jumping over the bar, all of which require a well-developed and co-ordinated nervous system.

It is not without interest to consider the part played by the psychological conditions under which sports should be carried on, the aim and object of which are to provide recreation for the mind, capable of inspiring real interest and of developing initiative and emulation. The organisation of competitive sports is the best means of sustaining the aspirations of sport enthusiasts, by taking into account the instinctive tendencies which prompt them to strive for supremacy. The individual aspirations and untameable daring of youth find no outlet in the monotony of daily life, and it gladly turns to the counter-excitement of competitive sports, where each is free to strive openly with all the strength at his command (Ruhemann).

Finally, Gerbis (1931) recommends physical exercises practised during rest periods interpolated during the working day. He considers this a means for preventing the ills which work may cause, and of increasing output by eliminating fatigue.

**Physiological Facts**

The influence of sports on the body has been the subject of many enquiries, but by far the most numerous of these have devoted particular attention to the reactions of the cardiac muscle.
Whereas radiological examination has demonstrated an increase in the volume of the heart after exercise, there is divergence of opinion as to whether it is due to hypertrophy of the heart or a simple functional dilatation, and as to whether these modifications should be considered to be pathological or not. Clinical examination makes it possible to recognize this hypertrophy or distension; and the claim has been made that a parallelism exists between this condition and the intensity of the exercises (Sirl).

The increase in the volume of the heart in the case of persons in training is, in the same exercise, about 24 per cent. higher than that observed in the case of persons not in training (Kaup and Grosse), and it is more or less accentuated according to the type of the sport practised. Thus, the heart is found to be largest in those who go in for swimming; medium distance races come next; then, in order, long distance races, medium distance races, wrestling, swimming and athleticism; and finally, with the heart the least developed, boxers. The shape also varies according to the nature of the sport; the right side is more developed in boxers; the left side is more developed in skiers (Herxheimer). Yet this increase is not an absolutely invariable condition; for the dimensions of the heart have at times been found not to exceed the normal (athletes: L. Merklen, Abrahams). As a general rule, when the athletic effort is taking place, a diastolic dilatation occurs, which can be demonstrated radioscopically by amplification of the cardiac beats; it disappears rapidly when the effort is over (Bordet). In all these cases it is a question of adaptation to the new conditions necessitated by the exercise, and not of cardiac failure. A strained heart is an unusual injury in sports (L. Merklen); serious physical exhaustion, leading to grave mischief or death, is due to general toxaemia and not to symptoms which are characteristic of a strained heart, and which are simply those of acute hyposystolic or asystolic action (F. Heckel).

The rate of the cardiac delivery per minute, greatly increased during athletic activity, has been variously estimated by experts: from 2 to 5 litres delivery during sleep; 20 litres or even more during hours of violent exercise; from 4 to 6 litres (Krogh and Lindhard) or even 9 to 10 litres (Hendersen) during normal delivery to 40 litres during exercise (R. Herbst). This increase is facilitated by a greater reflux of venous blood to the heart during exercise, a higher degree of venous pressure, due chiefly to actual muscular movements, which compress the muscular veins and drive the blood towards the large veins and the heart (L. Merklen).

Deutsch, however, observes that the respiratory movements peculiar to a man who engages in athletics, and the need for blood in the periphery, would entail a diminution in the heart. The temporary or permanent dilatation, which, nevertheless, is observed, would appear to be merely a sign indicating that the diminution must often take place under difficulties.

The increase of work thrown upon the heart is also accompanied by an acceleration of the pulse; the mechanism of this invariable condition has not as yet been explained. The rate may reach 150 or even 200 pulsations a minute, and this may last some time; the return to normal, after certain exercise, may even take several days.

In the case of persons in training, by force of the effort, there is noted a characteristic increase in the maximum arterial pressure, whereas the minimum is comparatively stable. The rates rapidly reach a level which they maintain the whole time the exercise lasts and thus they constitute the scale of effort. When the exercise is over, these modifications disappear and the pressure rapidly returns to normal. In the case of persons not in training, after a temporary initial rise to a maximum, the cardiac muscle gives way and a fall in pressure takes place (Merklen).

The surface of the vascular network is seen to be increased by a dilatation and an increased permeability of the capillaries in the tissues which breathe; this increase may be as much as double or triple that of the normal surface; it entails a diminution in the absorption of oxygen on account of the increase in the rapidity of the flow (Kaup and Grosse).

The modifications of the heart have been compared with those that take place in the involuntary vegetative nervous system: predominance of vagotony in persons in training (Herxheimer, Schrenk, Deutsch and Kaup); manifested in the form of hypertrophy of the skeletal musculature, weak blood pressure, diminution in the pulse rate, respiratory arrhythmia, increased galvanic excitability and exaggeration of the reflexes. These symptoms are found in a mild form in most persons trained for sports. *The flabby heart which has sometimes been observed corresponds to the vagotonic heart. In the same way the alkaline reserves of
the blood come into the picture of vagolony. Pulmonary action is stimulated by engagement in sports. Even mild exercise may increase fourfold or fivefold the amount of air absorbed and the vital capacity. In wrestlers a descent of the lower limit of the lungs has also been observed, varying according to the duration and stress of the wrestling bout; it disappears at the end of twenty-four hours (Lampe, Weltz, Heirich and Straubel).

Modifications of the circumstance of the abdomen have also been described, especially in wrestlers inclined to abdominal adiposity.

Metabolism in the case of persons engaged in athletics has been the subject of numerous investigations, which have emphasised the fact that an increase in the consumption of energy occurs according to the nature of exercises. The value of the respiratory quotient may go up to 2 or over. But this increase is not a sign of actual combustion, but merely an indication of an ebb in the carbon dioxide (bicarbonate of soda of the blood), brought about by neutralisation of the lactic acid, the quantity of which is increased (Schenk). In the case of persons not in training, the acid reaction of the blood, in spite of the presence of phosphates, bicarbonates and neutralising albumoid substances, must be partly connected with the presence of mineral phosphoric acid, which is found in increased amount in the blood of those who engage in athletics.

In the case of trained persons the respiratory quotient comes nearer to unity, this condition has been explained by the capacity which the body acquires of burning up directly hydrates of carbon, so economising the glycogen of the liver. Thus there would seem to be a "resynthesis" of glycogen and a simplification of the intermediary metabolism (Kaup and Grosse). The neutralising substances of the blood are also increased in the case of trained persons; in this way maintenance of the equilibrium in the concentration of hydrogen ions — the pH — in the blood is secured.

All these reactions of the body are produced only when it is a question of exercises characterised by moderate rapidity and effort. The performance of an exhausting feat brings about serious dyspnoea with retention of lactic acid (Hill), as well as a change in the level of the blood pressure and in the intra-alveolar tension of carbon dioxide (Herxheimer), which lasts for some time after the cessation of exercise and imposes a convalescence rather than a simple rest on the body.

As regards the sugar in the blood, it may be affirmed, with individual variations, that the reducing capacity can be increased up to 0.250 ern. per cent. But from this figure the percentage of the other reducing substances, which may go as high as 15 per cent. of the rate indicated above, must be deducted (Schenk). The alkaline reserve of the blood becomes diminished even after half an hour of fatigue; however, the pH of the blood remains within normal limits (Cannaro and Merenda).

In the urine, in most of the cases, an increase of acidity with pH=5.1 to 6.1 after the exercise has been observed, as compared with pH=6.2 to 7.2 in the state of repose (Schenk). A fairly large quantity of lactic acid is present; no elimination of lactic acid occurs in a state of rest. Diminished elimination of the hippuric acid occurs. Non-oxidised purin (methylguanidine and adenine) increases. The presence and the proportion of these substances in the urine have been attributed to an insufficiency of oxygen with a consecutive slowing down of combustion (Kuist and Flossner).

A transitory albuminuria, and especially an orthostatic albuminuria (Brandeis), have been observed in persons who engage in athletics. Their urine may also contain leucocytes, red corpuscles, hyalin and granulated cylinders, epithelial cells, crystals of calcium oxalate and uric acid. All these figured elements mentioned above are found, not only when severe exercises are performed, but even in persons who go in for such moderate forms of sport as football, ball games and running.

As the expenditure of energy by the body is increased by the practice of sports, it is obvious that the losses must be made good by suitable feeding. For this reason, in spite of the fact that one result of training is a diminution in the expenditure of energy (Atrler, Herbst and Lehmann), special diets have been devised for those who go in for sports, quite different from the diets which are considered suitable for following a life of habitual occupational activity.

In the diet of those who engage in athletics an increased ration of albumen and fat predominates. The supplementary ration thus provided for is not approved by all authorities; in other diet formulae special stress is laid on the need for increasing above all else the ration of carbo-hydrates (Gordon).
A table drawn up by Lorentz helps us to realise the quantitative modifications designed for increasing the production of calories:

<table>
<thead>
<tr>
<th>Foods</th>
<th>Habitual occupational activity</th>
<th>Training</th>
<th>Supplementary feeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat and cheese</td>
<td>600</td>
<td>1,800</td>
<td>1,200</td>
</tr>
<tr>
<td>Bread</td>
<td>750</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Potatoes</td>
<td>300</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>Fats, Butter, oils</td>
<td>800</td>
<td>2,400</td>
<td>1,600</td>
</tr>
<tr>
<td>Fruit, vegetables</td>
<td>450</td>
<td>500</td>
<td>100</td>
</tr>
<tr>
<td>Chocolate, sugar</td>
<td>250</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>Milk (to drink)</td>
<td>250</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>Total</td>
<td>3,400</td>
<td>7,750</td>
<td>3,850</td>
</tr>
</tbody>
</table>

**Pathology**

Excessive exercise imposes severe strain and may cause various lesions. Muscular lesions in particular may result from an effort made by a person who is subjected to a prolonged tension. A sudden pain is the typical subjective sign; objectively there is an apparent discontinuity in the muscular outline, or merely a localised diminution or exaggeration in muscular resistance. Subcutaneous rupture of the triceps in the calf has been observed in tennis players and has been designated "tennis leg". Mosenthal has observed the tearing off of the small trochanter, and Löhre the tearing off of the anterior and superior iliac spine. Women do not often suffer from muscular lesions; whereas older men do so more frequently than others (Rosenburg). Among the complications of these lesions, atrophies, calcareous deposits or points of ossification in the muscular tissue have been described (Batzner). The joints may become affected with irregularities of the surfaces, with wear and detachment of the cartilages, with arthritic projections, with calcareous concretions, and with periosteal neoplasms. A typical deformity of the elbow joint has been described in the case of tennis players (tennis arm); and Lloyd Williams has described under the name of "boxer's thumb" a metacarpophalangeal subluxation found among those practising this sport. Again, cases of costal fracture following effort have been reported by Arnold, Dubs and Mandl; cases of spontaneous rupture of the knee in wrestlers (tibial tuberositis), a case of rupture of the anterior cruciate ligament (Bresler); a case of rupture of the axillary artery by W. Koch; and cases of hemothorax by Illebrand.

Excessive exercise at certain sports has also caused serious ocular lesions, especially in tennis players following a blow from a ball, when retinal haemorrhage may take place, followed by somewhat serious complications (Gérard, Baxter). Auricular lesions have been observed in this same class of athlete, consisting in cases of rupture of the eardrum, auricular haemorrhage and suppurring otitis (Baxter). Virchow (1863), Lakaki in Japan and Valentin (1905) have drawn attention to cases of haematoma of the right ear in wrestlers. A much more serious complication has been observed in tennis players and is analogous to that described by Stradiotti in 1908 in the case of acrobats.

Similar modifications may be noted on the bronzes and statues representing ancient Roman wrestlers, as well as on statues of Hercules, which is a proof that this condition did not escape the notice of the artists of the time. Fervers has observed a case of necrosis of the scrotum after a lesion caused by sport; Nadler a case of rupture of the small intestines; Castrin a case of rupture of the kidney in a football player.

Close observation of a group of athletes brought to light a large number of lesions which in most instances do not come to the notice of a doctor, either on account of their mildness or on account of fear of expense that would be incurred by their treatment. Out of 484 cases of wounds and minor accidents observed in the pupils of a school of physical culture, there were noted: 56 unimportant lesions, 11.5 per cent.; 304 slight, 63.5 per cent.; 117 medium, 20.2 per cent.; and 17 serious, 3 per cent.

Lesions classed as "unimportant" did not require any interruption of exercises. Slight lesions necessitated a rest of from ten to fifteen days; medium ones a rest of from fifteen to thirty days; and serious ones an interruption of exercises during a period of thirty days or more. The moment when the injured person could resume exercise without harm was considered to be the moment of the "recovery."
as far as the physical training aspect was concerned; but this did not always tally with clinical recovery. According to their localisation, the various lesions referred to were classified as follows: joints, 185 or 38 per cent.; muscles, 57 or 12 per cent.; tendons, 42 or 8.5 per cent.; bones 53 or 11 per cent.; foot, 56 or 11.5 per cent.; lesions accompanied by haemorrhage, 91 or 19 per cent.

In conclusion, serious lesions are very rare, but slight lesions are common and very often have results which later on prevent the continuation of physical exercise (O. Schmith).

According to data supplied by a German insurance company in 1925, 8,681 accidents were caused by various sports among 2,500,000 insured persons aged under nineteen years. The insurance company remarked that contrary to what happens during medical examination for compulsory military service where the examinee may do his best to put up a show of pathological symptoms — the man who goes in for sports may strive to conceal any defect which might debar him from engaging in the exercise on which he is intent.

Data referring to the physical constitution of athletes are not very numerous at the present time. By way of illustration, the anthropometric and clinical calculations which were made on 192 athletes by Untermüller are shown in tables I and II (page 930).

Other forms of cardiac weakness have been noted in young men (2 to 6.4 per cent.), varicoceles among gymnasts (6), varicose veins (2), inflammation of the apices (3), kyphosis in young men (1) and in gymnasts (3).

As regards the influence of sport on the body, it is essential first of all to distinguish between exercises for which strength and skill are essential, and those which require endurance or swiftness. Then again, it must be recalled that all sports are not equally suitable for all ages. Their effect on the development of the body, and primarily of the heart and lungs, is greatest between the ages of fourteen and nineteen. It is advisable to recommend chiefly open-air sports, and also to see that enough time is devoted to them to permit of adequate training. For exercises where swiftness is essential, the years between nineteen and thirty would seem to be indicated; whereas between thirty and forty the exercises requiring strength and endurance are considered the most beneficial for the body. After forty, quiet movements are recommended, e.g. walking, mountaineering and boating, since they conform best to the possibilities of the body.

An attempt has been made to classify types of athletes. Thus the persons of the asthenic type (Kretschmer) appear to be athletes with power of endurance, with a capacity for prolonged resistance. Athletes having average strength would appear to conform to the same type, but to be distinguished from the latter. On the other hand the “syk nicotine” type (Kretschmer) is only very rarely inclined to the practice of sports (Kohrausch). Gymnasts, wrestlers,
### TABLE I. — ANTHROPOMETRIC DATA

<table>
<thead>
<tr>
<th></th>
<th>Young men up to 18 years</th>
<th>Gymnasts 19-35 years</th>
<th>Gymnasts 36-45 years</th>
<th>Gymnasts over 45 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of persons examined</td>
<td>31</td>
<td>141</td>
<td>12</td>
<td>8</td>
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<tr>
<td>Height (in cm.):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit of the variations</td>
<td>155-192</td>
<td>158-187</td>
<td>159-179</td>
<td>159-177</td>
</tr>
<tr>
<td>Average</td>
<td>167.2</td>
<td>168.0</td>
<td>169.9</td>
<td>169.9</td>
</tr>
<tr>
<td>Weight (in kg.):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit of the variations</td>
<td>42-47</td>
<td>49-79</td>
<td>50-95</td>
<td>70-80</td>
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<tr>
<td>Average</td>
<td>50.0</td>
<td>64.1</td>
<td>66.7</td>
<td>73.8</td>
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<tr>
<td>Length of trunk (in cm.):</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit of the variations</td>
<td>79-95</td>
<td>78-96</td>
<td>79-94</td>
<td>83-93</td>
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<tr>
<td>Average</td>
<td>86.4</td>
<td>87.6</td>
<td>88.0</td>
<td>87.8</td>
</tr>
<tr>
<td>Vital capacity (in litres):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit of the variations</td>
<td>2.3-4.9</td>
<td>2.3-5.5</td>
<td>2.4-5.4</td>
<td>3.0-4.0</td>
</tr>
<tr>
<td>Average</td>
<td>3.4</td>
<td>3.7</td>
<td>3.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Chest expansion (in cm.):</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Limit of the variations</td>
<td>3.0-14</td>
<td>1.0-14</td>
<td>3.0-14</td>
<td>2.0-7.5</td>
</tr>
<tr>
<td>Average</td>
<td>5.2</td>
<td>7.3</td>
<td>6.25</td>
<td>4.8</td>
</tr>
<tr>
<td>Manual strength (in kg.):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit of the variations</td>
<td>29.70</td>
<td>30.20</td>
<td>30.05</td>
<td>48.63</td>
</tr>
<tr>
<td>Right hand</td>
<td>27.70</td>
<td>30.70</td>
<td>32.65</td>
<td>48.70</td>
</tr>
<tr>
<td>Average</td>
<td>47.6</td>
<td>51.9</td>
<td>53.7</td>
<td>56.7</td>
</tr>
<tr>
<td>Left hand</td>
<td>46.0</td>
<td>49.9</td>
<td>49.0</td>
<td>49.7</td>
</tr>
</tbody>
</table>

### TABLE II. — CLINICAL NOTES

<table>
<thead>
<tr>
<th></th>
<th>Young men</th>
<th>Gymnasts</th>
<th>Gymnasts up to 40 years</th>
<th>Gymnasts over 40 years</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scolioses:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>3</td>
<td>17</td>
<td>4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Percentage</td>
<td>9.7</td>
<td>12.1</td>
<td>33.3</td>
<td>12.5</td>
<td>32.0</td>
</tr>
<tr>
<td>Lordoses:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>3</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Percentage</td>
<td>9.7</td>
<td>7.1</td>
<td>8.3</td>
<td>12.3</td>
<td>8.0</td>
</tr>
<tr>
<td>Tachycardia:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>9</td>
<td>3</td>
<td>14</td>
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<tr>
<td>Percentage</td>
<td>32.3</td>
<td>29.8</td>
<td>75.0</td>
<td>62.5</td>
<td>36.0</td>
</tr>
<tr>
<td>Flat foot or predisposition:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>10</td>
<td>66</td>
<td>7</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Percentage</td>
<td>32.3</td>
<td>46.8</td>
<td>58.3</td>
<td>62.5</td>
<td>32.0</td>
</tr>
<tr>
<td>Inguinal hernia or predisposition:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>3</td>
<td>11</td>
<td>6</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Percentage</td>
<td>9.7</td>
<td>7.8</td>
<td>50.0</td>
<td>12.1</td>
<td>-</td>
</tr>
</tbody>
</table>

and runners correspond to the athletic type (Basch). As a matter of fact, this classification does not always correspond to the individual aptitudes, and frequently champions belong to one of the athletic categories for which their constitution would not appear to be an indication.

At all events, the doctor is bound to intervene in questions relating to sport, whether it be that relatives become alarmed and consult him, or whether athletic associations (clubs) decide to organise amongst themselves medical and physiological supervision, so that their members may be guided according to their physical aptitudes, and so sawed, as far as possible, from the effects, which may sometimes be disastrous, of excessive or foolish indulgence in sports (Merkien).

### BIBLIOGRAPHY


Dr. A. Stocker

(I.L.O., Geneva).

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Starch Manufacture


The general term "starch" comprises a series of non-nitrogenous carbohydrate (C, H, O). It is made up of microscopic grains of special form found more or less abundantly in almost all vegetable cells.

The name "starch", however, is applied especially to the starchy matter in cereal grains (wheat, maize, oats, rice, etc.), and vegetables (chestnuts, etc.), while the name "leca" is applied to the same substance found in potatoes, manioc root, etc. All the same, these two names really refer to the same substance, differing only in the source, size and form of the grains.

Starch can be obtained industrially by grinding the grains of cereals after first having soaked them in water. During grinding a stream of water circulates over the grain and removes the starch, while the gluten accumulates and is collected on wire gauze, across which the grains of starch pass.

It can also be obtained by crushing the grain and allowing this to ferment for from fifteen to twenty days in five to six times its volume of water. As the result of fermentation, the gluten passes into solution, and by washings with water the starch is separated, collected and washed.

Other processes are based on direct chemical treatment of the cereals. Whatever the method, the starch collected is then dried in a stove and pulverised or broken up.

While rice yields 70-75 per cent. of starch and maize 65-67 per cent., wheat only yields 55-65 per cent.

Insoluble in cold water, starch swells in hot water without passing, strictly speaking, into solution and constitutes the well-known starch paste. The intense blue colour which starch gives with a dilute solution of iodine is very characteristic.

Starch is the first ingredient necessary for the manufacture of glucose and alcohol. It is used in dressing goods, in paper manufacture, hygienic powders, as an agglutinating material in colours, in pastes, in confectionery and pastry, etc.

Among sources of danger must be mentioned: dust raised by the grain, which is generally of poor quality or damaged (with, e.g., acari); starch dust, principally in stove drying; the steam and unpleasant smelling vapours, especially from the alkaline vats; the danger of fire or explosion from the starch, dust, etc.

Mention must be made, too, of the effect from inhalation of the starch dust in confectionery manufacture and the dermatitis resulting from pastes containing formalin or formaldehyde.

Ramazzini even had knowledge of cases of illness (headache, respiratory trouble, etc.) amongst starch makers where the work in question was carried on as a home industry. Thackrah reported on the same state of things in London, but enquiry by Arlidge was quite negative.

No statistics are available as to the health of the workers.

Preventive measures should take the line of closing openings on to main thoroughfares; insisting on concrete floors and walls cemented to a height of about 2 metres; on good general ventilation and exhaust ventilation locally applied where dust is given off; on provision of hoods over fermenting vats connected with ducts carrying gases and fumes to the boiler furnaces. Macerating tanks should be in the basement and have impermeable walls. Bolting, crushing and sieving should be done in closed apparatus. Residues should be removed daily, residuary water should not be allowed to run directly into streams, but should be
treated, e.g., on sewage farms; apparatus and machines creating noise should be isolated; all necessary measures must be taken to prevent fires and explosion from the starch dust.

**Stone Industry**


**Crude Materials**

The stone industry makes use of a considerable series of rocks which may be classified as hard or eruptive rocks, e.g., granite, basalt, and porphyry, and sedimentary or soft rocks, e.g., marble, alabaster, slate, sandstone, and lithographic stones.

The stone which is most widely used, but which is also the most dangerous to the health of stone-workers is sandstone (French, Gres; German, Sandstein; Italian, Pietra arenaria; Spanish, Piedra arenosa). All sandstones are sedimentary rocks, composed for the most part of quartz granules, varying in fineness, and held together by an agglutinating material, which may be argillaceous, silicious, or dolomitic; hence the names of silicious sandstone, calcareous, or dolomitic; hence an agglutinating material, which may be argillaceous, silicious, or dolomitic; hence the names of silicious sandstone, calcareous, or dolomitic; hence the names of silicious sandstone, calcareous, or dolomitic.

Silicious sandstone is the most difficult to work, but it is, on the other hand, the most resistant to weather. In practice the different kinds of stone are not distinguished according to their geological formation, but simply according to the locality in which they are found.

**Ganister** is a quartzite rock found in Great Britain; it is very hard and contains from 90 to 99 per cent. of silica; it is found under the coal measures. This quartzite does not melt even at high temperatures and is in consequence used for making bricks required for lining metallurgical furnaces and crucibles. The rock is generally obtained by blasting; the larger pieces are then broken by the hammer. The fragments are then placed in powerful crushing machines before being made into bricks. Much dust is liberated, particularly when large pieces are broken up by blows of the hammer.

**Buhrstone** is another very hard stone, perhaps the hardest of all known rocks; it is used in Great Britain for making millstones. This stone (which is found in France) is a variety of reddish-yellow flint.

**Grindstones** are made of calcareous or silicious sandstone or schist, the silicious variety being the most popular. There are soft, hard, and medium varieties. Eastern stones contain a kind of dolomite with the sand; the French contain mica; the American a kind of corundum.

**Lithographic stone** is composed of a special calcareous argillaceous material with traces of oxide of iron. It is very easy to polish.

Under the name of **marble** is included scientifically a variety of crystalline limestones with a characteristic granular appearance. Technically all varieties of granular and compact limestones which can be polished are included. The appearance and colour are very variable, depending on the nature and amount of heterogeneous substances present, such as metallic oxides, talc and fossil remains.

**Granite** is a crystalline rock, very abundant in nature, where it forms mountains; it is classed, as regards its dressing, among the hardest rocks. It is chiefly composed of a mixture of felspar, quartz and a coloured amalgam, which is generally mica or hornblend. In contrast to marble, granite is not affected by weather, but it is much more difficult to work. It generally polishes very easily.

**Alabaster** (French, Albatre; German, Alabaster; Italian and Spanish, Alabastro) is a limestone formed essentially of carbonate of calcium or sulphate of calcium.

**Slates** (French, Ardoises; German, Tafelschiffer; Italian, Ardesia; Spanish: Pizarra) are argillaceous schists, amorphous or of indistinct crystallisation, containing as impurities oxides of iron, lime or magnesia (see the articles "Alabaster" and "Slate").

**Lava** is a rock formed of a mixture of minerals, especially of silicates, thrown from volcanoes in a fluid or pasty state and then cooled and solidified on the outer slopes of the volcano as trachite, basalt, etc. Volcanic lava, chiefly used in the chemical industry, contains about 55 per cent. of silica.

**Serpentines or ophites** are formed of hydrated silicates of magnesia; they also contain iron. They can be easily polished and give a smooth homogeneous surface with a colour which recalls that of a serpent, hence the name.

**Porphyry** is a volcanic rock of a different kind containing crystals, quartz and felspar. Its colours are well known.

There must also be mentioned pebbles found in streams and rivers, of different sizes and shapes, but generally round. Pebbles may be found of varying composition and colour, of almost pure carbonates or of silica, and also of slate more or less rich in iron, manganese, etc.

**Industrial Operations**

The stone industry includes three principal groups of operations, the work (i) of quarrying or mining, (ii) of stone dressing, and (iii) of polishing.

Quarries are generally worked in the open; more rarely, like mines, they are underground. Open quarries are generally worked in ledges, either by
means of picks, wedges, or by spiral wire drills.

The blocks are often rough hewn and dressed on the site of the quarry. Underground work is similar to that in mines—explosives are used, while compressed air tools are coming more and more into use. (See articles "Mines", "Alabaster", and "Slate").

Stone-getting is carried out by labourers and quarrymen; the former remove the useless layer covering the stone which is being got, by means of pickaxes, spades, shovels, and occasionally explosives. The getting of the stone itself rests with the quarrymen. This occupation does not require what are called "skilled" workmen, but rather individuals having several years' experience and possessing strength. The danger is to a certain extent dependent on the kind of rock worked.

When the stone is dressed at ground level or at a slight height, the men work in a crouching position, which induces troubles of the circulation and of the muscles. The eyes are liable to accidents caused by particles of dust with sharp edges. Hernia is often caused by handling and lifting heavy stones. If stone is carried on the shoulder, tumours, such as fibrolipomata, may result. (See article "Alabaster." )

cement bricks.

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The danger from dust is strictly in accord with the chemical composition of the stone. It has been repeatedly stated that the presence of silica in dust is the essential factor in the production of respiratory lesions. Middleton, for example, has been led by his observations to the opinion that the effect of dust liberated by grinding wheels, made of artificial abrasives, is less serious than the effect of dust from sandstone grinding wheels (see also article "Abrasives"). If the particles of dust are sufficiently fine, pointed and sharp, the respiratory apparatus is more affected, for the dust can then reach very far into the respiratory tree.

The work of modelling and carving for designs and lettering is done by hand or by compressed air tools.

DANGERS

Apart from accidents, due to falls, landslides of masses of rock, and the use of explosives, which are particularly frequent and often serious to quarrymen, the principal danger certainly is from the inhalation of dust. It may be said that manual labour and the use of old-fashioned tools, that is to say, the application of old methods, are more favourable than work by modern mechanical methods—if indeed the term "favourable" can be used in this connection.

Ramazzini long ago emphasised the danger arising from the inhalation of dust liberated during hewing, cutting and polishing marble and stone, to workmen in this industry, a large number of whom become asthmatical and tuberculous. Whereas it is true that certain operations can be carried out by wet methods, it is also true that other work, or certain kinds of stone, do not permit the use of such methods. Moreover, the ever-increasing use of compressed-air tools, which do not lend themselves to the use of wet methods, raises enormous quantities of dust. This danger is all the more serious in that the work is usually done in closed shops.

The danger from dust is strictly in accord with the chemical composition of the stone. It has been repeatedly stated that the presence of silica in dust is the essential factor in the production of respiratory lesions. Middleton, for example, has been led by his observations to the opinion that the effect of dust liberated by grinding wheels, made of artificial abrasives, is less serious than the effect of dust from sandstone grinding wheels (see also article "Abrasives"). If the particles of dust are sufficiently fine, pointed and sharp, the respiratory apparatus is more affected, for the dust can then reach very far into the respiratory tree.
Before the tubercle bacillus can come into play and aggravate the pneumoconiotic lesion, there doubtless exists among stone-workers a clinical pre-tuberculous period which is well defined and can certainly develop without tuberculous complications (see articles "Silicosis" and "Occupational Diseases: Respiratory System"). It is difficult to draw up a list of stones according to their danger to the respiratory tree; they vary too often from country to country, and even from district to district in the same country. Nevertheless, enquiries made in different centres prove that the morbidity and mortality rates are higher among workers on sandstone, ganister and granite than among workers on limestone and marble. The dust of "buhrstone" has a very injurious effect on the respiratory apparatus, and this fact explains the excessive mortality found in Great Britain among workers in this industry. The dust of ganister is also very injurious for the men. But, according to Collis and Smith (1917), mixing ganister with clay for making refractory bricks, diminishes the risk of tuberculosis among the workers exposed to the dust.

Dust may also cause irritation of the mucous membranes of the eyes, nose and mouth, of the auditory meatus, as well as the skin. We must also note disease arising from exposure to cold; from the inhalation of fumes and toxic vapours during the use of explosives for getting the stone; from awkward positions during work: but above all, from humidity which exists in certain mines or quarries. This last trouble is equally common in workshops where the stone is worked by wet processes during sawing, planing, and polishing at the same time. It is necessary also to take into account the possibility of infection from dust, which may serve as the vehicle for such germs as actinomycosis, and ankylostomiasis from dirty water, as well as the possibility of poisoning from the materials used in polishing, e.g. lead poisoning from putty powder and oxalic acid. Troubles, such as headaches, have been reported from the use of explosives.

Some experts have drawn attention to the troubles and lesions caused among stone-cutters by compressed-air tools. During an enquiry carried out in the United States (1917-1918) Hamilton found 181 stonemasons suffering from "dead finger" caused by these tools: among 15 sandstone masons, 3 cases; among 38 limestone masons, 34 cases; among 50 granite masons, 43 cases; among 78 marble masons, 44 cases. But the affection was not serious. The use of these tools has also been correlated with a high death-rate among granite cutters (Hay). The introduction of pneumatic tools into the granite yards at Aberdeen was made very rapidly, so that by 1905 almost all the workshops were furnished with them, and the death-rate among stone-cutters and masons over 21 years was as follows:

<table>
<thead>
<tr>
<th>Period</th>
<th>Tuberculosis</th>
<th>Other pulmonary diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1895-1899</td>
<td>47</td>
<td>28</td>
</tr>
<tr>
<td>1900-1904</td>
<td>50</td>
<td>31</td>
</tr>
<tr>
<td>1905-1909</td>
<td>49</td>
<td>12</td>
</tr>
</tbody>
</table>

From 1895 to 1909 the mortality from pulmonary tuberculosis in the general population of Aberdeen was falling. During the period 1905-1909 fewer men were employed in the industry, and the reduction in deaths from other lung diseases indicates what should have occurred for tuberculosis.

Further, for the building section of the industry working in the open air, the proportion of all deaths due to phthisis was 25 per cent., while for the monumental section, working in closed sheds and so more exposed to dust, the proportion was 38 per cent. In fact research indicates that the danger is in proportion to the quantity of dust inhaled and to the length of time passed in the trade.

Statistics

An old enquiry made by Sommerfeld, which included 2,015 German stone-cutters, gives the following figures: 8.38 per cent. of hewers were tuberculous, 10.77 per cent. were suspected of tuberculosis, 8.15 average for the two); 17.97 per cent. were affected with respiratory diseases. Another enquiry, also quite old, that of Calwer, attributes to these workers an average of about 29 years for cutters, of 32 for polishers, and 38 for quarrymen. It must, however, be emphasised that there are inaccuracies in these figures, due to such factors as change of occupation in winter, interruption during military service, late entry into the work, etc.

Koelsch and Arnstein (1913) have made an investigation among 100 stone-cutters of Untermain (Bavaria), who were visited while at work in the workshops. Of 100 workmen examined, 23 were between 15 and 19 years, 29 between 20 and 29, 31 between 30 and 39, 13 between 40 and 49, and 5 above 50 years. Their social and hygienic conditions were bad; there was no efficient withdrawal of the dust; the workmen did not wear protecting goggles. Almost half (44) declared that their fathers had died of, or were ill with, respiratory diseases; and 41 of them that their fathers had been stone-
cutters as they were; 46 workmen complained of subjective troubles; 18 of cough with expectoration; 9 of thoracic pains. At the examination only 29 showed a completely normal condition of the respiratory system; the others all presented pulmonary lesions, 42 per cent. to a slight degree, 24 per cent. to a serious degree. In the three large stone-cutting works at Untermain, there were registered from 1900 to 1905, 139 deaths, which are classified as follows:

<table>
<thead>
<tr>
<th>Causes of death</th>
<th>Less than 20 years</th>
<th>From 21 to 30 years</th>
<th>From 31 to 40 years</th>
<th>From 41 to 50 years</th>
<th>Above 50 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuberculosis</td>
<td>3</td>
<td>25</td>
<td>36</td>
<td>31</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Respiratory diseases</td>
<td>—</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Other diseases</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>29</td>
<td>42</td>
<td>40</td>
<td>16</td>
<td>5</td>
</tr>
</tbody>
</table>

This shows a total of 113 deaths from tuberculosis out of 159, that is to say, 81 per cent., or almost four out of five. The sickness rate per 100 sandstone-cutters was in 1909 13.6 cases, with 850 days of sickness per 100,000, that is to say, 81 per cent., or almost four out of five. In the United States the number of stone masons in 1918 exceeded 100,000, and, according to different authors, conditions of health were stated to be most serious for those who dress the surface of stone.

One set of figures compares the mortality from all causes for the centre of Barre and Bedford; it is as follows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 30 years</td>
<td>22.98</td>
<td>7.64</td>
<td>28.39</td>
<td>4.05</td>
</tr>
<tr>
<td>30 to 49 years</td>
<td>65.35</td>
<td>46.23</td>
<td>52.43</td>
<td>47.18</td>
</tr>
<tr>
<td>50 years and over</td>
<td>11.69</td>
<td>46.13</td>
<td>19.18</td>
<td>48.77</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

If the figures are examined according to the type of stone worked, very high records are found, particularly for pulmonary diseases. Thus, for example, for masons on limestone in the United States and Canada (1913-1917) the causes of death claimed the following rates per 100,000: infections, 58.0; pulmonary tuberculosis, 385.6; pneumonia, 104.3; other respiratory diseases, 75.4; heart disease, 191.1; digestive system, 127.6; violence, 208.7. The death-rate for the general male population will be given later. For the period 1905-1918 the mortality is presented as follows:

<table>
<thead>
<tr>
<th>Number of persons exposed to risk</th>
<th>Number of deaths per 1000</th>
<th>1905-1909</th>
<th>1910-1914</th>
<th>1915-1918</th>
</tr>
</thead>
<tbody>
<tr>
<td>92,918</td>
<td>452</td>
<td>20.5</td>
<td>16.6</td>
<td>16.9</td>
</tr>
<tr>
<td>10,934</td>
<td>359</td>
<td>30.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12,590</td>
<td>915</td>
<td>16.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Except for the last three months of 1918.

In Austria, Bass has carried out an examination of stone-cutters in Vienna, and in 45.1 per cent. he found pulmonary lesions, of which number 29 per cent. were tuberculous. Diseases of the vessels are also common, especially various conditions of the lower limbs. From 1893 to 1904, 50 per cent. of fatal cases were due to tuberculosis, and 58.5 per cent. to respiratory diseases. The average age of workers at death was 46 years.

Australia. — The enquiry of Badham and Assheton, carried out in 1924 in seven quarries of New South Wales, was based on a medical and radiological examination of 15 workmen employed in crushing at a basalt quarry and of 9 workers at a marble quarry. In this investigation the experts did not meet with any case of pneumonoconiosis. The dust of felspar can be very dangerous, but if it is moistened, it does not cause trouble.

Of the 15 men employed working on basalt, 9 complained of difficult respiration, but the clinical signs of dyspnoea were only found in two; two workmen complained of rinitis and catarrh; one of bronchitis. The experts are of the opinion that, except for the crushers, the dust of basalt and dolomite produced negligible effects as regards the production of pneumonoconiotic fibrosis. They consider, however, that prolonged work at crushing can lead to the formation of fibrosis, rhinitis, etc.

A statement, dealing with the period from 1919 to 1924, made by the New York branch of the International Association of Granite Cutters, on the health of stone-cutters, shows that out of 52 deaths, registered in the period, 36.5 per cent.
STONE INDUSTRY

were certified as due to tuberculosis and 17.3 to pneumonia. The Association claims that 98 per cent. of all granite cutters were their members.

A recent enquiry (1924) of the Division of Industrial Health of the Labour Department of the State of New York on the health of stone masons has brought out the following facts: the men were of good physical appearance, even above the average. They had a resistance above the average to sickness, although the number of deaths was relatively high and in spite of the large proportion of deaths from respiratory affections.

The examination of 67 granite cutters showed 37 (55 per cent.) with damaged lungs. The danger from dust is undoubtedly very serious in this occupation. Nevertheless, the investigator estimates that the installation of apparatus for withdrawing the dust by suction (of which he gives interesting details) can greatly diminish the dangers.

In Great Britain (according to Collins) the death-rate of limestone masons (1910-1912) is quite favourable; when compared with standard population, aged from 25 to 65 years, it showed comparative figures of 129 for pulmonary tuberculosis (142 in the whole male population), 6 for Abrod tuberculosis (compared with 2), 38 for bronchitis (compared with 36), 54 for pneumonia (compared with 67), and 12 for other respiratory diseases (compared with 14).

Workmen employed on ganister suffer from pneumoconiosis, and Birmingham gives the death-rate for 1,000 workmen as 42.3 for ganister getters, 179.8 for crushers, and 28.2 for makers of ganister bricks.

United States. — The figures relating to granite cutters are numerous. Those of Vermont for the period 1913-1918 show a death-rate of 1,044.3 per 100,000, and those of New England a death-rate from pulmonary tuberculosis of 962.3 per 100,000 in 1912-1913, and of 1,056.7 in 1915-1918. In the Southern States, where the work is done in the open air, the death-rate from tuberculosis is limited to 441.1 per 100,000. At Vermont for the period 1910-1914 (before the general introduction of pneumatic tools), the granite workers showed a death-rate of 771.1 from tuberculosis compared with 125 for the whole population (per 100,000).

In 1917 the death-rate from the same cause was 1,095.5 per 100,000 compared with 96.4 for the whole population, and for the granite cutters of the United States and Canada, the death-rate from all causes was 25.7 (1917) per 1,000 against a rate of 18.1 for the male population of New England. In that country during the period from 1913 to 1917 the death-rate from different causes was as follows: death-rate (per 100,000): infections 19.1; pulmonary tuberculosis 1,002.7; diseases of the heart 175.3; pneumonia 161.6; violent causes 74. For the district of Barre and for 12,930 persons exposed to the danger during the period from 1911 to 1917, the death-rate per 1,000 was 20.11 for all causes, 11.84 for pulmonary tuberculosis, and 2.76 for other respiratory diseases. If it is desired to take into account the death-rate for all causes and by age groups, the following figures are obtained:

<table>
<thead>
<tr>
<th>Age</th>
<th>Granite cutters of Barre (August 1919)</th>
<th>Death-rate U.S.A. and Canada (1906-1919)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 30 Years</td>
<td>From 30 to 49 years</td>
<td>Above</td>
</tr>
<tr>
<td>22.96</td>
<td>65.35</td>
<td>7.64</td>
</tr>
<tr>
<td>11.69</td>
<td>46.13</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Below are also given statistics of the number of deaths from pulmonary tuberculosis among granite cutters of Barre, compared with the number of years of exposure to the dust (period 1896-1919).

Length of exposure Number of deaths
1 to 9 years 12
3 to 8 years 23
9 to 15 years 83
16 to 22 years 133
23 to 29 years 125
30 to 34 years 15

Total 399

The death-rate from all causes and from tuberculosis among this class of workmen in New England gives the following figures:

<table>
<thead>
<tr>
<th>Years</th>
<th>Number of persons exposed to risk</th>
<th>Deaths from all causes per 1,000</th>
<th>Number of persons exposed to risk</th>
<th>Deaths from pulmonary tuberculosis per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1905-1909</td>
<td>47,869</td>
<td>14.6</td>
<td>37,535</td>
<td>811.6</td>
</tr>
<tr>
<td>1910-1914</td>
<td>45,051</td>
<td>20.9</td>
<td>38,268</td>
<td>802.2</td>
</tr>
<tr>
<td>1915-1918 1</td>
<td>51,438</td>
<td>20.6</td>
<td>56,129</td>
<td>1,056.7</td>
</tr>
</tbody>
</table>

1 Except the last three months of the year 1918.

The death-rate is more serious for sandstone masons. For New England and for the period 1913-1917 the death-rate per 100,000 showed the following figures: 96 infections; 973.3 pulmonary tuberculosis; 144.2 diseases of the heart; 260.3 pneumonia; 204.3 other respiratory diseases; 132.1 violent causes. For all causes and for pulmonary tuberculosis compared with the whole number of persons exposed the figures are:

<table>
<thead>
<tr>
<th>Years</th>
<th>Number of persons exposed</th>
<th>Deaths from all causes per 1,000</th>
<th>Deaths from pulmonary tuberculosis per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1905-1909 1</td>
<td>12,850</td>
<td>22.3</td>
<td>910.5</td>
</tr>
<tr>
<td>1910-1914</td>
<td>11,393</td>
<td>25.0</td>
<td>804.0</td>
</tr>
<tr>
<td>1915-1918 1</td>
<td>5,146</td>
<td>25.8</td>
<td>1,029.9</td>
</tr>
</tbody>
</table>

1 Except the last three months of the year 1918.

In Great Britain the death-rate from respiratory diseases among this group of workmen appears very high in compar-
son with the death-rate for the standard population. As a matter of fact, for the period 1908-1909, the following are the comparative figures: 415 for tuberculosis (compared with 142 for the standard population); 49 for pulmonary fibrosis (compared with 21; 116 for bronchitis (compared with 38); 120 for pneumonia (compared with 67); 26 for other respiratory diseases (compared with 14).

Barwise made an investigation extending over ten years in Derbyshire among sandstone workers. He found an excessive death-rate from pulmonary tuberculosis, which among quarrymen was 29 per cent., whilst the same disease caused only 4.6 per cent. of deaths among agriculturists. On this basis in calculating the death-rate from tuberculosis without taking age into account, he found a rate of 5 per 1,000 among quarrymen and masons, dressing and quarrying stone, compared with 0.72 for agriculturists. The deaths from tuberculosis among sandstone masons are ten times greater than among limestone workers.

Formerly in France a heavy sickness and death-rate was known among the masons (see further on). Most regards marble, there are no available statistics, although Bertillon has drawn attention to high death-rates in this occupational group in France, Italy, and Switzerland. The figures, however, are often mixed with those concerning stone masons (see further on).

As regards stone, statistics are fairly numerous. In the State of Ohio, for example, in 1909 the death-rate from tuberculosis was calculated to be 29 per cent.; in the State of Massachusetts for the town of Quincy, during a period of 16 years and with a total of 343 deaths, there was a percentage of 41.4 caused by pulmonary tuberculosis, 12 from other respiratory diseases, 12.8 from diseases of the heart, 7 from violent causes. The average duration of life was, however, rather high: 47.8 years. But it should be noted that a sick workman may change his occupation for another, which is not so unhealthy and is less fatiguing, while remaining registered under the former occupation at his death; this falsifies statistics.

According to the Prudential Insurance Company of New York, the number of deaths from tuberculosis, among the cutters, planers and polishers of marble, is very high, reaching 40 per cent. of all deaths in the age group of 25 to 34 years and 34.4 in the group 35-44.

While this source of information shows us a relatively low death-rate from all causes for the age groups below 25 years, but higher for those above 25 years, it also reveals that the rate from pulmonary tuberculosis is excessive, for that rate is 5.41 per 1,000 for marble and stone-cutters compared with 2.65 for the industrial group, and 1.66 for that of commerce.

According to the census report (1908-1909) supplied by the Statistical Department of the United States showing 1,657 deaths from all causes among stone masons, 509, or 30.7 per cent., were due to pulmonary tuberculosis, which showed a percentage of all deaths of 43.5 for the age group 25 to 34 years, of 44.1 for the group 35-44, and of 41.6 for the group 45-54. Statistics of the Prudential Insurance Company for the period 1897 to 1914, when compared with the death-rate from tuberculosis among the male population in the registration States, give for marble and stone masons a percentage of 53.1 at ages 25-34, against 30.5 for the whole population; of 44.4 at ages 35-44 against 23.4; of 39 at ages 45-54 against 14.7; and of 26.7 at ages 55-64 against 7.7. An all-round percentage for all workmen aged 35 and upwards amounted to 13.9 as against 33.6 for stone masons.

In Great Britain the statistics used not to show stone masons separately, but included them under "quarrymen employed in working stone and slate" which diminished the heavy pulmonary tuberculosis rate. Nevertheless, investigations by experts have emphasised the excessive mortality from tuberculosis and respiratory diseases in this occupational group.

In 1900-1902 these statistics showed a comparative mortality from phthisis of 190 as against 186 for the whole male population between ages 25 to 65.

The average age at death of granite cutters, masons and polishers at Aberdeen during the period 1910-1919 was 48 years for cutters who died of tuberculosis, 61 for those who died of respiratory diseases other than tuberculosis, 62 for those dying of diseases of the circulatory and nervous systems, and 56 for all causes of death.

In Holland the death-rate of stone and marble cutters during the period 1908-1911 was as follows:

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of stone-cutters exposed</th>
<th>Mortality per 1,000 for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>all causes</td>
<td>pulmonary tuberculosis</td>
</tr>
<tr>
<td>18-24</td>
<td>2,424</td>
<td>2.9</td>
</tr>
<tr>
<td>25-34</td>
<td>2,506</td>
<td>3.3</td>
</tr>
<tr>
<td>35-44</td>
<td>1,412</td>
<td>16.1</td>
</tr>
<tr>
<td>45-54</td>
<td>1,368</td>
<td>21.9</td>
</tr>
<tr>
<td>55-64</td>
<td>700</td>
<td>32.6</td>
</tr>
</tbody>
</table>

Close collaboration between the public health services for combating tuberculosis,
those of the factory inspection department and the tuberculosis clinics made possible a radiographic examination in 1923 of 274 stone-cutters out of a total of 963 above 18 years who had occasion to visit the doctor. During this visit, attention was given to various factors which can play a part in health conditions of the workman, as well as to the danger of the occupation in general.

Of the 963 cutters 114 were aged from 20 to 25 years, 151 from 25 to 30, 308 from 31 to 40, 190 from 41 to 45, 108 from 46 to 50, 80 from 51 to 55, 57 from 56 to 60 years. Classification according to the number of years of work resulted as follows: 36 for less than 5 years, 65 from 6 to 10 years, 222 from 11 to 20 years, 324 from 21 to 30 years, 164 from 31 to 40, 150 from 41 to 50, 80 from 51 to 55, 57 from 56 to 60 years and one for 67 years.

The occupation of stone-cutter appears to have been carried on by many consecutive generations. The enquiry seems to show besides that men of poor physique do not choose this occupation. The majority of workmen examined felt in perfect health. Many of them, however, after questioning, coughed from time to time, but without expectorating. This is why there were but few opportunities for detecting tuberculosis by examination of the sputum. In 28 cases where this examination was possible, in only 6 was the tubercle bacillus found. By questioning the men it was brought out that this infection existed 8 times among grandparents, 66 among parents, 85 among brothers and sisters, 8 times among the wives, and 45 times among the children of stone-cutters.

The greater part of the workmen work exclusively at freestone (571), very few at sandstone and chiefly freestone (241); 102 worked at other stones, such as marble and granite. The masons bring home a piece of stone home with him to finish, and it also happens that a mason may take a piece of stone home with him to finish, but the economic advantage is annulled by the danger which arises to health.

The workshops are generally well arranged hygienically and give the impression that much has been done in this respect, thanks to the law, for stone-cutters.

As regards the consumption of alcoholic drinks, it seems to have much diminished during the last 10 to 25 years. Young workmen are usually abstainers, or small consumers of alcohol. The same may be said regarding the habits of smoking or chewing.

Very few masons wear respirators, and many do not even wear goggles.

The clinical examination was supplemented by a radiographic examination. It enabled a positive diagnosis as regards pulmonary lesions to be made in 135 cases which had clinically been found negative.

<table>
<thead>
<tr>
<th>Years of employment</th>
<th>Number of affections clinically positive and negative to X-rays</th>
<th>Number of affections clinically negative and positive to X-rays</th>
<th>Number of affections clinically positive and also positive to X-rays</th>
<th>Number of affections clinically negative and also negative to X-rays</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6-10</td>
<td>19</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>11-20</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>21-30</td>
<td>4</td>
<td>50</td>
<td>34</td>
<td>17</td>
<td>105</td>
</tr>
<tr>
<td>31-40</td>
<td>2</td>
<td>24</td>
<td>20</td>
<td>3</td>
<td>59</td>
</tr>
<tr>
<td>41-50</td>
<td>2</td>
<td>11</td>
<td>8</td>
<td>4</td>
<td>29</td>
</tr>
<tr>
<td>51-60</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Totals</td>
<td>9</td>
<td>135</td>
<td>97</td>
<td>33</td>
<td>274</td>
</tr>
</tbody>
</table>

The use of X-rays for detecting pulmonary lesions among stone masons has proved the necessity of arranging a medical examination for adults. This enquiry has also resulted in organising conferences in the various departments of the Dutch Federation of Stone Cutters by experts and medical inspectors, in order to make known to those concerned the occupational risks and the best means for preventing them.

In Switzerland, according to the Health Insurance Office, for men in the building trade at Zurich for the period 1900-1911, the sickness rate of stone-cutters recorded at the Office was as follows:
When this rate of sickness extending over twelve years is compared with that for certain other groups of workmen, the stone-cutters are found to present a sickness rate of 41 per cent. against 30 per cent. for locksmiths.

The Swiss Association of Stone Workers return, for the years 1903-1911, a total of 3,889 members, shown in return, for the years 1903-1911, a total of 3,889 members, shown in the statistics with an average of 22.6 per cent. of sickness of an average duration of 39 days for each case. The diseases of the respiratory system numbered 44 per cent., of sickness extending with an average of 22.6 per cent., of sickness of an average duration of 39 days for each case. The diseases of the respiratory system numbered 44 per cent., of sickness extending

<table>
<thead>
<tr>
<th>Year</th>
<th>Number insured</th>
<th>Full number</th>
<th>Percentage of</th>
<th>Number of</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900-1903</td>
<td>767</td>
<td>403</td>
<td>53</td>
<td>13,653</td>
<td>35.94</td>
</tr>
<tr>
<td>1904-1907</td>
<td>365</td>
<td>231</td>
<td>63</td>
<td>5,769</td>
<td>20.47</td>
</tr>
<tr>
<td>1908-1911</td>
<td>392</td>
<td>245</td>
<td>61</td>
<td>5,072</td>
<td>20.47</td>
</tr>
<tr>
<td>Average</td>
<td>126</td>
<td>73</td>
<td>58</td>
<td>9,041</td>
<td>27.16</td>
</tr>
</tbody>
</table>

An investigation organised by the National Tuberculosis Association of the United States (1919) showed that in the districts where marble was worked the death-rate from tuberculosis was lower than in other districts, and the same held good for districts where slate and talc are obtained.

The same conclusions can be drawn from English death-rates. According to those for 1919-1921 the comparative figures for deaths from respiratory diseases compared with figures for deaths of the standard population, were as follows:

<table>
<thead>
<tr>
<th>Material worked</th>
<th>Deaths</th>
<th>Death-rate per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slate</td>
<td>93</td>
<td>111.3</td>
</tr>
<tr>
<td>Marble</td>
<td>91</td>
<td>97.1</td>
</tr>
<tr>
<td>Granite</td>
<td>525</td>
<td>143.0</td>
</tr>
<tr>
<td>For the whole State, omitting the districts concerned with the three kinds of stone</td>
<td>2,301</td>
<td>82.3</td>
</tr>
<tr>
<td>For the whole State</td>
<td>3,220</td>
<td>90.6</td>
</tr>
</tbody>
</table>

An investigation by the writer, the death-rate from tuberculosis due to different kinds of stone is as follows:

<table>
<thead>
<tr>
<th>Material worked</th>
<th>Deaths</th>
<th>Death-rate per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slate</td>
<td>93</td>
<td>111.3</td>
</tr>
<tr>
<td>Marble</td>
<td>91</td>
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</tr>
<tr>
<td>Granite</td>
<td>525</td>
<td>143.0</td>
</tr>
<tr>
<td>For the whole State, omitting the districts concerned with the three kinds of stone</td>
<td>2,301</td>
<td>82.3</td>
</tr>
<tr>
<td>For the whole State</td>
<td>3,220</td>
<td>90.6</td>
</tr>
</tbody>
</table>

According to Swiss statistics for the period 1902-1911, the average age of these workmen was 35 years.

It may be useful to bring together here in a single table figures relating to masons on different kinds of stone. Thus for New England we get the following:

**DEATHS FROM ALL CAUSES PER 1,000 (PERIOD 1915-1918)**

<table>
<thead>
<tr>
<th>Material worked</th>
<th>Deaths</th>
<th>Death-rate per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slate</td>
<td>93</td>
<td>111.3</td>
</tr>
<tr>
<td>Marble</td>
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<tr>
<td>Granite</td>
<td>525</td>
<td>143.0</td>
</tr>
<tr>
<td>For the whole State, omitting the districts concerned with the three kinds of stone</td>
<td>2,301</td>
<td>82.3</td>
</tr>
<tr>
<td>For the whole State</td>
<td>3,220</td>
<td>90.6</td>
</tr>
</tbody>
</table>

**DEATHS FROM PULMONARY TUBERCULOSIS PER 100,000 (PERIOD 1915-1918)**

<table>
<thead>
<tr>
<th>Material worked</th>
<th>Deaths</th>
<th>Death-rate per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slate</td>
<td>93</td>
<td>111.3</td>
</tr>
<tr>
<td>Marble</td>
<td>91</td>
<td>97.1</td>
</tr>
<tr>
<td>Granite</td>
<td>525</td>
<td>143.0</td>
</tr>
<tr>
<td>For the whole State, omitting the districts concerned with the three kinds of stone</td>
<td>2,301</td>
<td>82.3</td>
</tr>
<tr>
<td>For the whole State</td>
<td>3,220</td>
<td>90.6</td>
</tr>
</tbody>
</table>

Mathew Hay has shown that at Aberdeen the death rate from tuberculosis among granite workers is at least three times higher than the average rate for young men of 21 years and rises to almost 6.2 per 1,000 at all ages. Collis found that granite-cutters who work in closed workshops show a smaller chest expansion and more respiratory trouble than do men working in the open air. According to the same writer, the death-rate from pulmonary tuberculosis due to different kinds of stone is as follows:

<table>
<thead>
<tr>
<th>Material worked</th>
<th>Deaths</th>
<th>Death-rate per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slate</td>
<td>93</td>
<td>111.3</td>
</tr>
<tr>
<td>Marble</td>
<td>91</td>
<td>97.1</td>
</tr>
<tr>
<td>Granite</td>
<td>525</td>
<td>143.0</td>
</tr>
<tr>
<td>For the whole State, omitting the districts concerned with the three kinds of stone</td>
<td>2,301</td>
<td>82.3</td>
</tr>
<tr>
<td>For the whole State</td>
<td>3,220</td>
<td>90.6</td>
</tr>
</tbody>
</table>
Death-rates per 1,000 living: coalminers 1.0; masons (limestone) 1.4; miners (iron) 1.5; miners (lead) 3.9; granite cutters 6.2; masons (sandstone) 16.7; ganister-work 22.3.

**Pathology**

Generally speaking, stonemasons have a superior physique, which would lead one to expect them to offer a greater resistance to disease. But statistics show that, on the contrary, these workers are unusually prone to respiratory diseases and to tuberculosis in particular. Although autopsies have not been made which would enable the quantity of silica dust contained in the respiratory tree to be determined, and although the nature of the dust inhaled calls for further scientific research, yet the available figures show that the danger lies particularly in the quantity of silica present in the dust inhaled. An American enquiry of recent date (1922) shows that for all the stone-cutting centres of the United States, the deaths due to tuberculosis and to non-tuberculous respiratory diseases (bronchitis, pneumonia, asthma) among granite workers have been increasing, whereas there has been a general diminution for adult males of the rest of the population.

The wearing down of steel tools which is quite common in the case of certain varieties of stone, such as ganister and quartz, gives rise to metallic dust, which also plays a certain part in the production of respiratory diseases.

It is obvious that among these workers, diseases of the respiratory system occupy the first place: rhinitis, pharyngitis, bronchitis, pneumonia and especially the pneumoconiotic form improperly called "silicosis" which is frequently complicated by tuberculosis. This is a matter which urgently calls for the attention of experts, for very often the diagnosis of phthisis is made in the case of lesions which are non-tuberculous. (See articles "Tuberculosis", "Diseases of the Respiratory System", "Dust", etc.) As long ago as 1913 Sleeswijk, of Delft, expressed himself very strongly against the readiness with which the dogma was accepted that "dust equals tuberculosis amongst stone cutters", and he desired that this dogma should be submitted to the severest criticism. It is necessary to examine carefully the patients concerned and to make a very conscientious differential diagnosis. He recalls, for example, that Elias in his thesis, 1909, on stone-masons reported that among 104 masons of 21 to 50 years, 38 showed on examination, symptoms of pulmonary lesions (tuberculous), or were suspected of having such; but that only in the case of two out of 24, who had been recognised as tuberculous, were bacilli found in their sputum.

As the result of an enquiry in the Elbsandstein district, Domann (1925) considered that the lungs of stonemasons show characteristic lesions which should not be mistaken, as is often the case, for pulmonary tuberculosis. Examination by X-rays can help the differential diagnosis, but Domann admits that there still remain in this matter some very obscure points.

Every clinical effort, by examination of sputum, radiography, and where necessary observation in hospital, should be made to arrive at a true diagnosis with a view to adequate and early intervention. The Medical Silicosis Bureau of South Africa, the Mines Department of the United States, the Medical Inspection Department of Holland, the official and private agencies of Germany and Italy, a technical committee formed on the suggestion of the Minister of Commerce of New South Wales, 1925, etc., have undertaken, or are about to undertake, a series of general investigations into the action of mineral dust on the respiratory system, making particular use of radiography.

Among these investigations mention may be made of that undertaken in Italy by C. Bianchi (1928) on the frequency of tuberculosis among Carrara marble workers, and that undertaken in the United States (1929) in the granite industry, in which the workers are exposed to dusts very rich in silica. The latter enquiry has brought out the close relationship between exposure to dust and state of health. The constant presence of silicosis with special radiological characteristics; manifest susceptibility to tuberculosis, generally appearing after twenty years' work; lesions almost invariably at the base of the lung and terminating fatally; the relationship between duration of exposure to dust, and the tuberculosis incidence and fatality rates; the relationship between tuberculosis morbidity and duration of employment of pneumatic tools; the high incidence of diseases other than tuberculosis.

In Great Britain an enquiry by Sutherland, Bryson and Keating (1929) on granite brought out the incidence of silicosis among the granite workers. Of the 494 examined, 290 were suffering
from fibrosis. Radiography showed that among 211 workers there were 36 clear cases of silicosis. Another report of 1929 by Sutherland and Bryson deals with cases of silicosis found among sandstone workers (buildings under construction, quarries). These authors examined 454 workers, including 266 by radiography, and found fibrosis, probably silicotic, among 112, chiefly those aged between forty-five and forty-four years.

In France, Heim de Balsac, Agasse-Lafont and Feil (1930) drew attention to occupational pneumoconiosis among sandstone paving workers (hewers and quarriers).

Digestive troubles are also common, due in part to the large quantity of drink taken by the workmen, to be explained in part by dryness of the throat from dust. Work in wet workshops, especially those for polishing, causes forms of rheumatism which are often accompanied by laryngitis and tracheitis. An irritant effect at the back of the mouth is also caused by the materials used in polishing, such, for example, as oxalic acid.

Accidents to the eyes are very frequent, due to fragments from the tools, spicules of stone and other foreign bodies. The conjunctiva and cornea are very often the seat of injuries and ulcers, which may become complicated in consequence of infection. Bass found at Vienna that 48 per cent. of young workmen and 78 per cent. of old had been victims of eye accidents.

Nerve troubles have been reported among masons making use of compressed-air tools. One cannot, however, regard them as special occupational diseases. Southard and Salomon have reported a case of cramp in a granite cutter (see article "Pneumatic Hammers").

A rare and interesting case of paralysis of the left vocal cord following upon pleuro-pericardo-mediastinitis in a patient suffering from pneumoconiosis was described in 1931 by Lacroix and Wild.

Among the stone-breakers and crushers callosities of the hand are noticed, set up by the pressure exerted by the tools; according to Bramwell, a scleroderma caused by the handling of chisels in cold weather seems to be quite frequent, as well as lesions of the palm caused by limestone and lime. The hands are dry, hard, and swollen; the skin scales and peels; the nails become brittle, thin and are streaked along the length of the nail; the interdigital skin is very inflamed and shows incrustations on a level with the articulations. The dust may also cause eczema of the external ear and of the auditory meatus, and even irritation of the tympanic cavity.

The lesions of the hand and fingers, especially of the index, may become infected and complicated by whitlow and phlegmon.

Very painful lesions are caused by lime and oxalic acid.

Figures from the above sources also show a great frequency of accidents among stone-workers: it is sufficient to mention blasting, falls of masses of rock, transportation, breaking and crushing by hand, in order to understand the cause of this frequency. Hernias, ruptures of muscles, and lumbago are fairly common results of the exertions demanded by work on stone.

**Hygiene**

The organisation of work in stone quarries and mines should take into account the measures laid down for coal mines, in all that concerns, for example, work in galleries, drilling, the use of explosives, ventilation, lighting, and the removal of water. Accident prevention during the raising and removal of blocks of stone demands very particular attention, for very often the moving of stone from the face to the exit of the quarry or mine calls for great force and is dangerous work.

Stone may be worked either in the open air or in workshops. In the first case the workman should be protected against the injurious action of wind, of draughts and bad weather (Germany, Denmark). German legislation also provides measures for quarry workers, who are to be protected against the action of the sun, either by roofs, or by sheds closed on three sides. These measures are also adopted by Holland.

The workshops should have a smooth impermeable floor, which should be washed down each day on the conclusion of work; if the work is done wet, provision must be made for draining away the water (Denmark). The height of the workshop is not allowed to be less than 10 feet in Denmark and 11 feet in Holland; in Holland floor space is also called for sufficient to provide each worker with not less than 20 cubic metres of air, which must be renewed; there must also be good lighting and adequate cleanliness of the workshops (Denmark, Holland). Provision of spittoons, respirators and goggles is also
laid down by legislation both for quarrymen and for those employed in the workshops. In Danish and Dutch legislation it is besides laid down that work on silica stones shall be done wet, and that each man shall be at least 1½ metres from the next; and in Holland 2 metres when working on sandstone.

The German legislation also provides that when sandstone is being worked, there should be a distance of at least 2 metres between each banker. The raising of dust, as well as the spraying of slush from apparatus and machinery, must be suppressed as much as possible.

The workmen employed in carving stone with compressed-air tools should be protected against dust by a helmet covering the whole head, into which air enters under pressure. In Holland measures are taken to prevent dust caused by work on stone with compressed-air tools from spreading about, but it should be removed by adequate means.

Every quarry and every workshop ought to be provided with cloakrooms and overalls, which should be waterproof (if the work is done by a wet process), lavatories in sufficient number (1 for 5 workers), towels for each person (to be changed each week) (Denmark, Holland), drinking water, canteen with necessary means for keeping and warming the food brought by the workmen; closets, etc.

German legislation provides for the installation, at the quarries, of rest rooms (Aufenthaltszimmer) lighted, with a level floor, warmed in winter, with sitting accommodation for the workers.

The moistening of blocks of stone, especially during very hot weather, if there are no technical objections, is also laid down for sandstone in Germany and Holland. Moreover, similar measures must be taken for other kinds of stone. In dry weather the floors of the workshops (Holland) must also be kept wet.

It is desirable to provide adjustable bankers for the workmen so that the stone blocks can be placed at the most convenient height for work and the workmen need not get into uncomfortable positions.

Whenever occasion permits it, wet methods should be used for crushing and polishing; when they cannot be employed, then the best means must be adopted to catch the dust at the place where it is generated and to evacuate it from the workshop.

Research work was carried out in the United States in 1930 to determine the best methods of collecting the dusts arising when granite is worked with the surfacing machine or pneumatic tools (which give off the most dust) (Hatch, Drinker, Choate).

It is the workmen's duty to take the greatest possible care with regard to their food and personal hygiene, in order to insure good conditions of resistance against infection by tuberculosis; it is equally the duty of the employers to provide for healthy conditions in closed workshops. Enquiries made in different countries show that in the centres concerned there is no accurate appreciation of the seriousness of the danger from dust to the health of workmen in general, and in particular to stone masons. That is why the Dutch Government has decided upon the following rules: one shift to three hours and a half, followed by a rest of at least half an hour. The Commission of enquiry of the United States suggests for granite workers, time for recreation and holidays from time to time long enough to increase their resistance to disease.

In Denmark it is compulsory to post up the Regulations laid down by the Government.

The Industrial Arbitration Court of New South Wales (Sydney) fixed, in November 1925, forty hours' work a week for sandstone quarrymen. The arbitrator based his decision on the statistical documents put in evidence, which proved the unhealthiness of quarrymen's work.

The Health Service of Ohio published in 1914 the following recommendations:

Employers should co-operate one with another to fight against the frequency of pneumonia and tuberculosis by observation of the following measures: engage only men of good physique especially in the case of young workmen; instruct workmen on the occupational risk of their work; institute periodical medical examinations; only carry out machine planing and sawing by a moist process, using mineral oil; clean workshops daily; provide openings in the walls at a level with the floor, or rather at about 1 metre in order that the dust, which is rather heavy, may not rise in the atmosphere; install where possible local suction apparatus, especially in the case of machine work.

LEGISLATION

Women are excluded from work in stone quarries in Germany and Greece; women of less than 18 years are, however, admitted to some processes with the sanction of the administrative authority and for a six-hour day's work. They are absolutely excluded from any carrying work.
workmen possesses a valid stone-cutter's card. This card is issued on request by the burgomaster, when he has received from the applicant the completion of his fourteenth year, provided that the workman possesses a valid stone-cutter's card. The Regulations also lay down measures, for preventing the liberation of dust from elevators and sieves, for the care of the floors of workshops, and for the use of respirators in stone-cutting workshops.

The following affections found among stone-cutters are subject to compulsory notification in Holland: silicosis and tuberculosis, silicous dermatitis, silicous rhinitis, silicous ophthalmitis, and silicous conjunctivitis. The English Regulations of 1919 for refractory materials provide that stone-cutting by hand shall be done in the open air, and that crushing and grinding must be done in machines provided with adequate means for the removal of dust, or done by a wet process or in closed apparatus. The Regulations also lay down measures, for preventing the liberation of dust from elevators and sieves, for the care of the floors of workshops, and for the use of respirators in stone-cutting workshops.

The first general examination of adult stone-cutters took place in 1923.

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requirements of hygiene and morality; efficient protection against dangers from traffic, especially for the workmen employed on railways and roads.

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Straw


Straw is composed of the stalks and ends of certain cereals (wheat, rice, barley, rye, oats, etc.) which have ripened and dried, that is to say, the plants have died in a natural manner. As a type of straw may be taken straw made from grain or from wheat. In fact, the term "straw" usually designates straw got from wheat, whilst for other kinds the plant of origin is specified, for instance, rice straw, barley straw, oat straw, etc. It should also be recorded that the world production of wheat straw exceeds alone and by a good deal that of all other types.

Data concerning the pathology of workmen handling wheat straw being included in operations connected with straw in general, efforts will here be confined to dealing principally with pathological manifestations due to wheat straw either in the agricultural industry or in industrial establishments.

The harvesting of wheat dried in the sun occurs in the hot months and is effected by means of a small hand sickle and less frequently with a large scythe. In certain regions (Northern Europe, France Flanders), the Flemish scythe is used. Elsewhere, where the nature of the ground makes it possible and in the case of extensive fields, reaping machines are used. The cut grain is gathered in sheaves and undergoes final ripening. Thereafter the sheaves are transported to a threshing floor for threshing, which has the effect of freeing the grain from seeds and ears. This operation is done by hand or by the help of animals or by machinery. Threshing furnishes, on the one hand, grain and, on the other, straw and chaff (composed of fragments of stalks, ears and waste foreign matter) — secondary products, but nevertheless of great economic value.

PATHOLOGY

In the Agricultural Industry

During harvesting and threshing operations the workers are exposed to a series of occupational pathological manifestations represented by accidents (use of scythes, reaping machines or mechanical threshing machines), to sunstroke and heatstroke, and to fevers caused by continued exhaustion on prolonged working days commencing at dawn and finishing at dusk with very short rest intervals during the day. At times even the Sunday rest is not observed, for once the grain is ripe the harvest may not be deferred in order to avoid the loss of a certain amount of grain. As characteristic occupational injuries connected with the harvest there should be recalled certain forms of teno-synovitis, often affecting harvesters using the sickle. At times there is a painful swelling, characterised by crepitation situated at the exterior side of the pulse and the lower third of the right forearm and affecting the sheathes of the abductor muscles of the thumb (Palizzari). In other cases there is noted acute synovitis of the wrist and extensor sheath of the left hand (Bonazzi). In the first case the lesion is due to the repeated and prolonged passage of the hand from a state of hemipronation to hemisupination, whilst the thumb in a state of prehension manipulating the sickle accomplishes considerable effort. In the second case the harvester cuts the stalks with the sickle, which he holds in his right hand, and gathers them into sheaves with the left hand, thus
accomplishing an almost circular abduction movement of all the upper limbs, the forearm being slightly bent back on the arm. In consequence of this movement, repeated during several hours, the hand effects movements of prehension and flexion on the forearm, and it is precisely these movements which give rise to forms of acute synovitis of the pulse and of the extensor tendons of the fingers of the left hand.

These forms of inflammation, most usually serous and easily healed (severe cases are very rare), affect in general weak subjects during the first days of the harvest, that is to say, while they still lack practice.

Another injury, characteristic of harvesters and of distinctly traumatic origin consists in small wounds of the cornea and sclerotic, caused by ears of cereals (wheat, rye, etc.). Abrasions of this kind frequently set up profound ulceration and sometimes even, in the case of local infection, the much-feared serpiginous ulcer, which is often followed by hypopion.

Thresholding, whether manual or mechanical, raises large quantities of organic and inorganic dust. The workers who work threshing machines and who travel with these machines from one field to another or from one farm to another are engaged on these operations over a period of several weeks and often contract acute forms of bronchial catarrh (generally without fever) as a consequence of the inhalation of irritant dusts. Where it is a case of persons subject to chronic bronchial catarrh and, in addition, to emphysema and asthma (recurring bronchial asthma), such injuries aggravate the effect of the conditions and the patient often falls a victim to serious asthmatic attacks. On this account, work connected with threshing and similar operations should be prohibited for all workers showing predisposition to forms of bronchial and asthmatic catarrh.

Straw forms a part of cattle fodder, but it is chiefly used in combination with chaff for animal bedding in stables and byres. When the straw is stored or has to be transported it is commonly couch'd up in bales, which are bound together with wire. Compression of straw is effected by the aid of special machines worked by hand or mechanically. Wherever threshing machines, compressors or other machines involving the use of solid or liquid combustion agents are used, the presence of toxic fumes must be reckoned with (especially carbon monoxide), if such operations be

affected in badly ventilated places, etc. These machines, and particularly the threshing machines, are likewise the cause of accidents, sometimes of a very serious order. Amongst the workers engaged on threshing machines, those most exposed are the workers who load these machines.

Straw and chaff are frequently a source of infection, at times very serious, for man as well as for animals. Characteristic diseases connected with wheat which may be transmitted to man include different parasitical infections of a cryptocomic nature: rust disease of plants caused by fungi of the Uredineae group; by a fungus of the Ustilaginaceae group, etc. The latter, however, is rather a possible theory than a practical occurrence. In fact, whilst certain of these causes may give rise to disease in man (for instance the so-called "wheat itch" or pruriginous dermatitis due to Acarus tritici, known also as Poediculoides ventricosus), grains disseminated in the chaff and in the straw is usually too sparse to be greatly feared as transmitting agents of infection.

On the other hand, the straw and the chaff are much more frequently the vehicle of diseases common to stall animals and to man. This is true of certain fungi which live on vegetable refuse, a type of which is the actinomycoses (see article "Actinomycosis").

Straw is a very dusty substance which often, when piled up in damp places and even when exposed to the air, develops mould and may transmit to man diseases caused by moulds (Aspergillus fumigatus and Niger). The spores may be inhaled at the moment of removing contaminated bedding. This disease is not uncommon amongst cattle. Amongst men, the Aspergillus fumigatus may even be found in the lungs (Pneumomycosis aspergillicana), whilst the Niger has only caused certain growths affecting the walls of the exterior auditory meatus or the Membrane tympani.

Straw used for bedding or for clean-lind mangers and drinking troughs and even the animals themselves may transmit foot-and-mouth disease, vaccine, tuberculosis, swine fever, erysipelas, glanders, rhages, anthrax, etc. (see these articles and also the article "Infection").

As regards the agricultural industry, there should not be overlooked the use of straw for animal fodder, necessitating the use of machinery (chopping machines), which often give rise to deep wounds, sometimes even involving amputation of part of the upper limbs.
In the Manufacturing Industry

Straw is used as a protective material in the packing of fragile objects, for covering chairs and armchairs, for the manufacture of baskets and mats and especially for that of hats, and also in the manufacture of certain kinds of paper.

At the present time, efforts have succeeded in producing a substance known as "maizolithe" with straw as a basis and this substance seems to give excellent results as an insulating medium and in the manufacture of small objects. The straw is reduced to small pieces, treated with caustic soda, washed, transformed into a gel, boiled and dried.

Straw also serves for the preparation of a special kind of carbon utilised in the manufacture of powders and explosives (Hengst powder or Hengstite); it is also used in the manufacture of wood-shavings, wood-cotton, wood-wool, etc.

In the packing industry, as in other branches of industry in which straw is used, it is not an uncommon thing to meet with small wounds situated on the hands of the worker, wounds which may become directly infected. Gaston and Bolzer have described two cases of whitlows due to sporotrichosis occurring amongst workmen engaged on stuffing with straw.

The straw hat industry and the artistic manipulation of straw for hats comprise various operations and manipulation of the straw, which are of interest even if consideration is confined merely to hat manufacture as executed in Italy, Switzerland, Germany, China, Japan, etc. For hat-making different types of wheat straw are used — in Italy, especially the variety known as *Triticum aestivum* Linn. The following observations all refer to Italy, for as a result of certain comparisons with hat manufacture in other countries it is found that the Italian industry and the technology which it produces are more or less the same for workers in all districts where straw is plaited either by itself or mixed with hair, silk, etc.

Straw for hats, after having been treated, is gathered in sheaves and exposed to the sun for drying, then subjected to bleaching (dew and sunshine, the harvest taking place after the first spring heat), and finally it is picked. This operation consists in detaching from the stalk the part which is situated above the last knotty exccrcence and which carries the ear. The worker engaged in this operation seizes with the right hand one or several stalks of straw at a time whilst with the left she holds the sheaf of straw on her knees. This work gives rise to forms of occupational cramp, sometimes painful and sometimes spastic, and always affecting the right arm. Picking is an operation which creates relatively little dust unless the straw, and especially the offshoots, contain a certain amount of dried earth. The straws are passed through a perforated plate to separate out the thick straws from the finer ones. Thereafter they are cut in two, the upper part, namely that which carries the ear, being the finer ("point"), whilst the lower part is much thicker ("stalk").

The straws are first subjected to bleaching by means of sulphurous fumes, then plaited by hand in such a way as to produce flat plaits of some millimetres in thickness and several metres long, the fineness of which varies according as to whether they have been made with the tips of straws or the stalks of the straw and in accordance also with the kind of straw used. Hats are made from this plaited straw which is sewn by hand or by machinery. The work of plaiting the straw is a fine, methodical and continuous operation resembling, as regards precision and rhythm, machine work. This precise, rhythmic operation often causes a form of occupational cramp which is at times bilateral and most frequently affects the right arm. Painful forms accompanied by paresthesia and more rarely spastic in character have been met with, affecting the fingers, the wrist joint and even the right forearm (Giglioli, Pieraccini). The picking and plaiting of straw may cause characteristic callosities situated on the hands and on the volar surface at the point where the straws exercise greater pressure, and likewise deformities on the fingers, especially on the distal parts of the index and on the left middle finger (Martinuzzi).

When in hat-making the straw plaits are sewn by hand into concentric and superimposed rings, the woman worker (these operations are always done by women) is obliged from time to time to stretch the straw with a view to flattening the straw material, or, in other words, to pull it out. This operation causes the formation of large callosities, intense wearing away of the nails and even deformations of the phalanges. The pressure exerted in the course of drawing out the hat on the radial side of the thenar eminence and on the side of the metacarpal phalangial joint of the right thumb...
causes inflammation of the tendon sheaths of one of the abductors or extensors of the thumb, thus giving rise to the condition designated in Italy as "spring finger". This condition is, however, sometimes caused by the extensor muscles of the left thumb as a result of the facts above described but of repeated efforts (with the thumb flexed) which the workers engaged in plaiting exercise during the pulling out of the hat. Amongst persons who sew the hats by hand there has at times been observed the occurrence of occupational spams.

For bleaching hats, they are passed through solutions of various substances (acid bisulphite of potassium and sodium, liable to liberate irritant sulphur fumes) and they are thereafter placed in a closed chamber where they are exposed to sulphur fumes.

In the case of a worker engaged in removing straw from bottles and scraping with his nails mouldy straw which has stuck to these, Dreuw noted the formation around the nails of a friable mass which had even caused injury to the fingers. Microscopic examination showed the presence of hyphomycetes recalling very closely trichophyton.

The reports of the German factory inspectors for 1920 contain references to cases of conjunctivitis due to solvents, and in 1927 there were noted toxic manifestations among workers engaged in the manufacture of straw hats for women who used a product known as "Z varnish", which was replaced, after prohibition, by other kinds of varnish, which, unfortunately, possess similar harmful properties. The symptoms were as follows: headache, watering of the eyes, vomiting, nervous trouble, attacks of syncope; and locally, exanthema, dermatitis and sub-cutaneous cellulitis.

Caustic soda used for washing the straw with a view to the preparation of "half stuff" has also caused cutaneous troubles amongst workers coming into contact with the caustic solution.

Hygiene

The hygienic measures which it is desirable to apply are particularly connected with the use of reaping and binding machines which cut the grain and tie the sheaves; protection of forage from moulds by adequate storing in covered places subsequent to ripening and drying, etc.

In certain cases bleaching by sulphur may be advantageously replaced by bleaching with peroxide of hydrogen (see article "Bleaching"), which would constitute considerable progres from the hygienic aspect.

The protection of the worker handling straw, however, is always connected with the agricultural industry. Mechanical work, provided that safety is effectively guaranteed, shortens the duration of the work, which is often very trying, and reduces the number of workers occupied and the daily fatigue involved.

In Japan, boys under fifteen and girls under twenty-one years of age are excluded from dusty operations connected with straw.

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Strontium


Strontium (symbol Sr) is an alkaline-earth metal the properties of which resemble those of two other elements belonging to the same group: barium and calcium. It is found in the natural state in the form of carbonates and sulphates, almost invariably mixed with barium and calcium ores, and in small quantities in certain mineral waters and in sea water. The metal is obtained by electrolysis of molten chloride of strontium. It has a silvery white or yellowish colour, melts at 800° C., and commences volatilisation at about 950° C. Amongst its compounds the most important are the bromide, the carbonate, the chloride and the nitrate, etc.

The various compounds of strontium are utilised in the sugar industry and in the manufacture of Bengal lights. From the point of view of industrial hygiene, the various compounds are considered as harmless (Lehmann and Löwy).
Salts of strontium possess properties similar to those of barium compounds. On the digestive system they exercise a fairly slight toxic effect, having a purgative action. Injected into the veins, the toxic action is manifest, since strontium constitutes a poison of the heart. According to experiments effectuated by Rahuteau, salts of strontium abolish muscular contractility. Nevertheless, lesions attributable to the various compounds of strontium are but little known.

Sandri (1931), by methodical research effected on animals (hens), has studied the effect of a titrated suspension of carbonate of strontium administered per os and capable of occasioning phenomena of motor paralysis. The study dealt with the peripheral reticulum of the nerve cells (ganglion cells of the anterior column of the spinal marrow).

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**Studios (Cinema)**

**Pathology**

Amongst the occupational diseases to which cinema artistes are exposed may be distinguished two types of affections: first, those common to actors on the stage in general, and secondly, those particularly connected with studio life.

The first type has been studied in the article devoted to "artistes". It may be recalled here that amongst cinema artistes, skin affections due to make-up should not be overlooked, more especially on account of the very extensive quantities of cosmetics, etc., which are used.

Alcoholism and epilepsy constitute contra-indications for the occupation of cinema artistes. Dreyfus (1892) demands that candidates should be certified as immune from either of these. The same authority examines candidates for work of this kind in testing presence of mind by the forefinger test.

Affections specially connected with studio work have in consequence of the development of the cinematograph industry, been made the object of special study by eye and skin specialists. The most typical form of cutaneous lesion is represented by what is known as electric "sunstroke". The patient suffers from swelling of the face and especially of the eyelids, which are reddened and affected with an intense pricking sensation. The lesion develops fairly rapidly and soon there occurs desquamation of the epidermis followed by a brownish pigmentation which is more or less persistent.

Lesions of the eye are more serious. The lesion is characterised by a latent period during which the sufferer complains of a trying sensation of pricking similar to that caused by pricking with a needle or by the presence of grains of sand in the eyes. This sensation increases later, becomes persistent, and finally gives way to dull pain. The conjunctivae are red and at times raised by inflammatory infiltration. There is abundant secretion. The eyelids become sticky and small crusts form along the edge of the eyelashes. This blepharitis is accompanied by palpebral spasm, photophobia, watering of the eyes and asthenopia.

Chappe described in 1920 before the French Congress on Ophthalmology cases of conjunctivitis due to the action of light amongst cinema artistes.

Adam reported in 1922 amongst artistes in German studios a large number of cases of conjunctivitis which very closely recalled follicular conjunctivitis. In 1922 similarly, Reichert, of Berlin, found amongst people engaged as "supers", or "crowd artistes" in the studio, a whole series of slight irritations of the conjunctiva, and among artistes a form of acute catarrh with blepharospasm, oedematous inflammation of the globe, hyperaemia of the iris, all symptoms being accompanied by violent ocular pain. He found serious lesions similar to those caused by sunlight and by reflected light from snow. These cases follow in general a fairly mild evolution, but there has at times been noted as sequelae changes in the macula with scotoma and vacciniform hydroa of the eye (case of Friede, 1921).

In 1924 Sedan noted in two cases corneal complications (forms of keratitis). Though serious symptoms are rare, the possibility of lesions of the internal eye must be reckoned with, especially in the case of predisposed subjects and those presenting notably certain effects of refraction (myopia, etc.). In one of the cases described by Sedan, the artiste had suffered from attacks similar to the initial attack for a period of five years, though he had completely given up the cinema from the first appearance of the lesion (Sedan, 1929).

In an Odessa studio, Rabinovitch (1927) noted cases of photophobia caused by ultra-violet rays. It was chiefly a case of erosions and of opacity of the cornea, the lesions being
localised at those points on which the light struck vertically.

Hoorgina (1929) examined 205 cinema workers (mechanics engaged in the maintenance of the lighting equipment, actors, directors and assistants) and found numerous hypertrophy of the conjunctiva with a tendency to disappear as a result of interruption of the work. He attributes these lesions to the action of luminous radiations and remarks that the latter may cause even superficial forms of keratitis, notably amongst new and inexperienced actors.

All the cutaneous and ocular lesions are due to the same cause: the excessively bright lighting to which artists working in a studio are exposed. Work in bright sunlight is, moreover, not without danger either. The very powerful arc lamps, incandescent lamps filled with gas, and mercury vapour lamps used in the scenarios for providing “sunlight” effects are well known. It is their luminous and blinding intensity and in particular their richness in ultra-violet rays which provoke the affections, at times fairly serious, referred to above. This problem has for several years received the attention of specialists: Verhoeff and L. Bell- (1921), Elvy, Bossu, Comandon, Polack (1923), as well as the various publications issued by the Illuminating Engineering Society (United States, Great Britain), the American Academy of Art, the Society of Motion Picture Engineers. These studies have drawn attention to the danger for the human system, and in particular for the eye, involved by radiations from certain luminous sources. Doubtless there should not be overlooked that heat in which the artists are at times obliged to work and of which the lamps in question are sometimes the cause; heat which gives rise to headache and a sensation of oppression which only disappears in the open air. Yet the danger comes chiefly from the blinding glare of the luminous source and from the infra-red, blue and ultra-violet rays emitted by it.

The eye possesses, it is true, means of defence against luminous traumatism, amongst which figure in the foreground movement of the retinal pigments and the contraction of the pupils.

On the other hand, the ultra-violet rays are absorbed by the cornea and the crystalline lens, which reacts by giving rise to painful transient symptoms.

Where, however, the luminous source is very intense or exposure to it very long, very serious lesions may be produced. The limit of brilliance of and contrast which the human eye can stand varies, moreover, in different individuals.

It is certain that a certain amount of tolerance can be acquired, and that amongst scene-shifters, electricians and studio veterans there are many who can withstand much more rays than neophytes the intense glare from the lighting projectors. This faculty of adaptation does not, however, prevent the organ of sight from becoming frequently attacked by the above-mentioned lesions which necessitate the adoption of definite means of prevention.

**Prophylaxis**

Prevention of these affections is a complex problem. The demands made by photographic and cinematographic technique are often in contradiction to the steps necessitated in order to effect the provision of adequate protection for the eyes of the artistes. The lens used for taking pictures requires a certain quality of light and the exclusion of all radiations except those without danger to the eyes of the artistes is not possible from the technical point of view. On the other hand, artistic effects sought in making certain films necessitate big changes in the intensity of the light and at times lighting placed at a short distance from the face when it is necessary to register fine shades of expression. It is known that any lighting source or reflecting surface having a brilliance exceeding 7 Lambert (about 22 lux per sq. cm.) causes ocular pain. It would be advisable, therefore, as soon as this limit is exceeded to take measures calculated to counteract the effects of undue brilliance. These measures consist in the use of diffusing globes (indirect or semi-indirect systems); in the arrangement of the lamps and projectors, etc., in the upper part and on the walls of the studio; and in the removal of objects with brilliant surfaces from the field of vision of the artistes. It is possible likewise to take precautions with a view to avoiding the sudden switching on of light and rapid changes in intensity. In the case of very intense lighting being necessary, it should not be used except during a very short period and artistes should not be subjected to it except at sufficiently long intervals.

The prevention of lesions due to radiations with great refrangibility is more difficult. While it is relatively simple to deal with liberation of ultra-violet rays, it is not equally so in the case of violet and blue rays which, as has been seen, likewise present a certain danger for the sight.
As regards ultra-violet rays, the glass tubes of the lamps used render harmless radiation in consequence of its absorption. The same is true of the powerful arc lamps unless in the case of a naked light being used. They should therefore be provided with a glass globe to absorb ultra-violet radiations.

In this manner it is possible to prevent serious retarded symptoms, to be feared in the case of cinema artistes (Vigouroux, 1928).

Unfortunately, ultra-violet rays are not the only harmful rays, and the globes referred to do not succeed in retaining the violet and blue rays which suffice to give rise to ocular lesions. The only means of dealing effectively with the danger from harmful radiations would be to intercept between the lighting source and the eyes of the artistes a screen of yellow glass. In this way it would be possible to obtain a light free from harmful radiations. In practice, however, this is difficult since the ordinary film is not sensitive to light sifted through the yellow screen, and it would not be possible in order to counteract this effect either to prolong the time of exposure or to intensify further the lighting. There is therefore a single means of dealing with the problem: that is to modify the film (Polack). The problem to be solved therefore consists in discovering a panchromatic emulsion possessing, besides adequate stability and faculty of conservation, a rapidity almost eight times greater than that of the present panchromatic film. This problem would not seem to be impossible of solution. There are already known processes of hyper-sensitivity which increase considerably the rapidity of the emulsion. Up to the present time they still possess the defect of rendering the film subject to spontaneous alteration and thus reducing the period of its conservation to a point which is inadequate.

The importance of the risk run by artistes during the shooting of films led the German Federal Health Office to issue (1928) a warning leaflet dealing with protection of the eyes of those exposed to the violent luminous radiations in studios. In this leaflet, those affected are informed as to the effect of the ultra-violet rays and of the intense lighting on the eyes, as well as of effective means of protection. General hygiene in the studio does not differ in any particular from the hygiene of workshops intended for any kind of human labour.

As regards modern methods of lighting in studios, reference should be made to the paper by W. A. Villiers and to the discussion to which it gave rise in the English Lighting Association (18 February 1930), and also to that by Cabet (Bulletin de la Société française des électriciens, November 1930).

Particular attention should be devoted to ventilation in lighting and shooting rooms.

Bellon has already drawn attention (1922) to the question of ventilation in operators' boxes, the air renewal in these places constituting an almost more urgent necessity at present in consequence of the technique of the talking films, where the operators are isolated in cages, so to speak, with soundproof walls, unless in rare cases, where they are situated in a room adjoining the studio — which arrangement would naturally be ideal, but is unfortunately very often difficult to carry into effect.

**LEGISLATION**

Social legislation relative to the cinema industry adopted in the different countries — Austria, France, Germany, Italy, United States (California and New York) — deals only with the protection of children, regulating the age of admission and the length of the working day.

**BIBLIOGRAPHY**

The bibliography available on this subject is fairly extensive: cf. the quarterly publication of the International Labour Office: Bibliography of Industrial Hygiene.

Submarines


The quite special conditions applying to men on undersea craft and submarines have opened up an entirely new and extremely interesting chapter in the realm of naval hygiene. Medical literature on this subject is comparatively scanty and is almost exclusively Italian; the contributions of other countries, e.g. Great Britain, the United States and Japan, are very limited. This fact may be explained both by the difficulties of experimental research on the question, and by the need for keeping secret the internal equipment of these vessels.

Undersea craft, in the original sense, being henceforward abolished, naval construction at the present time is confined to submersible torpedo-boats or
*submarines* only, that is to say, vessels which travel on the surface, but are able at any moment to dive to such a depth as to make themselves invisible and invulnerable.

Without going into the technical details of construction, it is only to mention here that the largest submarines can dive to a depth of 120 metres. The number of men carried may be sixty or more. The interior form of the various types is very nearly the same; it is only the methods used for diving which differ widely.

The dive is achieved by automatically filling special compartments with seawater, which enters through openings in the external hull and the double bottom, which are provided with valves. The return to the surface is normally carried out by expelling the water from the compartments by means of rotary pumps driven by electric motors. In exceptional circumstances compressed air is introduced. These operations take place very quickly, in two to three minutes. The duration of the immersion may be prolonged to even more than twenty-four hours.

Navigation below the surface is silent, the electric motors running without noise. Exterior vision is almost nil; but it is assured by periscope when the vessel is partially submerged.

As far as the interior structure of submarines is concerned, it need only be recalled that the compartments connect with each other, and that in certain types (e.g. Laurentia) a passage exists in the space between the two hulls which enables a man to pass from bow to stern without going through the battery compartment. This is a very good arrangement, for if, by some accident, seawater penetrates into the battery compartment and comes into contact with the sulphuric acid, chlorine is liberated, which renders the air irrespirable.

The crew's quarters are situated in the central compartments, and, at least in the more modern types, a certain degree of comfort is provided. As far as the kitchens are concerned, electric cooking does not use up oxygen from the surrounding air. Originally sewage was removed by means of non-odorous containers, which were, however, the source of various unpleasant conditions. The construction of lavatories with a double valve and pump, which drives out the faeces by means of a jet of compressed air, represents a very important advance.

The average cubic space per individual is, on certain submarines, round about 15 cub. metres, with, however, considerable variations between one compartment and another, from a minimum of 6.5 cub. metres to a maximum of 48. Although these values are greater than those for ordinary vessels, they, nevertheless, suffice only for a total submersion of a few hours' duration. The average cubic space is calculated on the supposition that the compartments communicate with each other. Naturally it varies when the doors are closed.

Propulsion is effected either by internal-combustion engines, with liquid fuel, or by steam turbines when the vessel is on the surface or partially submerged, and by electric motors for navigation below the surface. The internal-combustion engines have the advantage of heating the surrounding medium less than the turbines. It is true that turbines can be placed in a special compartment and can be provided with fans. The internal-combustion engines, by driving the dynamo, can also charge up the batteries of accumulators which supply power to the electric motors for navigation during submersion. The direct current motors are driven by accumulators containing sulphuric acid or an alkaline solution. The accumulators are hermetically sealed so as to prevent the escape of the electrolyte or the liberation of gases formed as the electric power is generated.

The Edison alkaline accumulators used on American underwater craft do away with the use of sulphuric acid and so eliminate the liberation of sulphur dioxide or chlorine gases, which render the air irrespirable. They take up considerably less space, and require less maintenance. However, from the technical point of view, they are inferior to the sulphuric acid type.

Compressed air at 150 to 180 atmospheres pressure is stored in steel drums.

**Sources of Danger**

**Changes in the air of the vessel during submersion.** — From the hygienic point of view, a submarine is of particular interest when it is travelling completely submerged; under these conditions it forms a hermetically sealed space, immersed in, and completely surrounded by, a large liquid stratum, which separates it from the outer air.

The causes of change in the internal atmosphere are chiefly due to the functions of organic life of man, the effects of which are peculiar to submarines because of the hermetic sealing of the space. There must be taken into account the pollution of air brought about by the biological functions of man (see article "Air of the Work-room").

Combustible liquid may foul the air, either by the small quantities of vaporised fuel which leak through joints and valves and mingle with the atmosphere, or by such poisonous products of combustion as carbon dioxide, steam, nitric oxide, which changes into a hyponitrite, nitrous acid, nitric acid, methane and acetylene, varying with the quantity and quality of the fuel used. This vitiation of the air must especially be taken into consideration when submersion has taken place immediately after stopping the engines when there has not been time to ensure a sufficient
change of air. The working of the electric motors also affects the air; but, as the accumulators are hermetically sealed, the gases generated — hydrogen, sulphuretted hydrogen and sulphur dioxide — cannot penetrate into the compartment. Finally, lubrication with heavy mineral oils, containing more or less considerable quantities of light oils having their boiling point below 200° C., leads to the generation of poisonous products.

Furthermore, a rise of temperature occurs by reason of the operation of the internal-combustion engines, of which a considerable part of the calories produced is radiated into the compartment. In the case of electric motors, about 17 per cent. of the average power furnished is transformed into heat energy. This radiation is greater when the accumulators are fully charged. The rise of temperature is, however, lessened by the operation of fans, provided that submersion does not follow quickly after stopping the engines.

Secondary causes of chemical and physical pollution of the air are: artificial lighting, varnishes which in oxidising withdraw oxygen from the air, the escape of compressed air from increase in pressure, and the stirring up of dust by the movement of the motors.

After several hours of submersion, a peculiar smell, irritating to the mucous membranes, due to sulphur dioxide and hydro-carbides from the motors, becomes noticeable.

The physical and chemical alterations of the air in submarines have been studied experimentally by Belli and his collaborators; the results obtained may be summarised as follows:

Concerning the physical state of the air the temperature is, to begin with, 2-3° C. above the outside air; it equalises itself after a time with the temperature of the water outside. In general, it may be said that the temperature keeps within limits which are tolerable for life. In temperate seas during the cold weather, it is rather cool, but the crew protect themselves easily with clothing and electric heating. In summer, the temperature sometimes exceeds 30° C. and may become trying by reason of the high degree of humidity which accompanies it.

The relative humidity may touch 90 per cent. or more. In some places saturation is reached. During submersion, aqueous vapour accumulates in the air, and, little by little, it increases the humidity, both relative and absolute. Naturally, saturation is quickly reached in winter, on account of the low temperature, with a relatively low degree of vapour pressure. In summer, because of temperatures exceeding 30° C., the excessive humidity of the air causes a disagreeable sensation, which is accentuated after a certain period of submersion.

Barometric pressure is 10 to 30 mm. above that outside, with variations which are a little irregular. Its increase is due to the liberation of hydrogen and other gases generated in the operation of the accumulators, and especially to the escape of compressed air.

The chemical changes are far more important than the physical changes and are characterised by a decrease in oxygen and an increase in carbon dioxide.

The reduction in the percentage of the oxygen is greater than that due to the consumption of this gas by the vital processes of the men — organic combustion — for part of the oxygen obviously goes to serve other oxidations of the hydrocarbides of the motors. In a submersion of normal duration the amount of oxygen remains sufficient for breathing. Belli and Olivi found that after six hours of submersion the minimum percentage was 18; because of successive renewals of the air — still during submersion — there was an increase to 19 per cent. which was maintained throughout the whole time of observation, i.e. eighteen hours. It is plain, therefore, that they were far above that minimum percentage below which asphyxiation is produced, 3.5 per cent.

In a British submarine where the volume of air per person was 4.25 cubic metres, and where the crew numbered sixteen, estimates made after twenty hours of submersion gave 16.37 per cent. of oxygen (Shaw and Gérad).

The proportion of carbon dioxide varies according to the activity of the persons present; like the reduction of oxygen, the increase of dioxide is greater than that occasioned by the vital activities of the human organism. According to Belli and his collaborators, this increase appears to be gradual, and at the end of six hours to reach 31 parts in 1,000. By renewing the air every five hours it was possible to obtain a concentration varying between 13 and 17 parts in 1,000 after each renewal. The amount rose rapidly to 31, and after twenty-four hours reached 37.2. But no serious phenomena of poisoning have been reported.

In an English submarine, after twenty-six hours of submersion, the concentration of CO₂ had reached 9.4 per 1,000 without either objective or subjective troubles being noticed among
the sixteen men. It was by no means the same when a fresh experiment was tried during which no measures were taken to lessen the amount of carbon dioxide.

Hydrogen is physiologically an unimportant gas, which is liberated from the accumulators during charging; but it may become dangerous, for in given proportions it can form an explosive mixture with the air.

Sulphur dioxide is an unbreathable gas which exercises a vigorous action on the human body when it is inhaled. For rabbits its harmful action starts at 0.05 per cent. It becomes fatal at about the end of 4 hours at 0.24 per cent. A maximum content of 0.314 grm. per cub. metre of air has been found in submarines at the end of twenty hours. This amount, although small, is sufficient when added to that of other gases to explain a feeling of suffocation. For rabbits its harmful action starts at 0.1449 grm. per cub. metre of air; this small quantity is liberated by the electric motors.

Chlorine is generally absent, but it may be given off occasionally should the sea-water penetrate into the accumulators; in this case, it may be the cause of very serious accidents.

Even at the beginning of submersion, hydrocarbides may be detected. The small amount of 0.1449 grm. per cub. metre has been found, which is due to products from the evaporation of naphtha rather than lubricating oil.

Carbon monoxide, ammonia, nitrous and nitric oxides are always absent.

On the other hand, arsine and arsine, hydrogen may occasionally be present, as a result of abnormal reaction in the accumulators. Two instances of general asphyxiation have been noted on Italian submarines. The electric accumulators were blamed as they were not hermetically sealed, and also the ventilation hole in the container was in direct contact with the living room atmosphere. The lead plates were enclosed in sheaths of asbestos so as to prevent the lead oxide crystals which form on the positive plates from precipitating. Now the asbestos contained arsenic, whence originated the arsine and arsine, hydrogen which was given off into the air during the operation of the accumulators. Similar cases have been observed in France after two immersions each of eighteen hours, and in Great Britain, where cases of asphyxiation have been caused by the use of lead plates contaminated with arsenic. The gaseous discharge occurs particularly during the charging of the accumulators. To prevent such accidents it is necessary to use plates of lead, free from arsenic, and sulphuric acid which does not contain more than 0.0008 per cent. of it by weight. Moreover, vigorous ventilation of the accumulators must be assured during charging and for one hour after the completion of this operation.

Apart from these exceptional cases of asphyxia, the crews of Italian submarines have never experienced much trouble, except for headaches, mental stupor, and, exceptionally, forms of lethargy after many hours under water.

Physio-Pathology

Theoretically, air conditions differ in the various compartments; in practice, these differences tend to disappear, for the communications allow the air to mix, and the only real difference is that between the highest and lowest parts, owing to carbon dioxide being heavier than air.

Tests of the exact extent of these changes would be very useful for warning the crew of any threatening danger. This would be all the more useful seeing that the sense of smell — which is of use elsewhere — no longer responds in these atmospheric conditions, after some time has been spent breathing air contaminated with gases exerting different reactions.

Such small animals as mice and guinea-pigs were formerly used on board to detect the presence of carbon monoxide; but they are no longer used at present, for it is recognised that there is no need to fear this danger on submarines. Nor is the lighted candle of value; for even in an atmosphere harmful to man there always remains sufficient oxygen to feed the flame.

The maximum limit of concentration of carbon dioxide, fixed at 1 part in 1,000 in city areas, is quickly reached — in half an hour — in submarines during submersion. If one accepted a test of this nature, it would be necessary to raise the limit to 15 in 1,000, which corresponds to about half the maximum quantity — 50 parts per 1,000 — recorded in several tests, and perfectly well tolerated. Automatic apparatus (Drager, Ausell, etc.) may be used for indicating the content-limit of carbon dioxide in the air, e.g. when the content reached is 15 parts in 1,000.

On the other hand, it is unnecessary to equip submarines with apparatus for indicating the amount of oxygen, because, although the air may be rendered irredeemable by carbon dioxide, there is still sufficient oxygen for breathing.

In submarines totally submerged there is no question of being able to
use the outside air. Thus it is always the same air which passes several times through the lungs; a veritable rumination of the atmosphere. Consequently it is necessary to restore the chemical constituents of the air present in the vessel.

While it is comparatively easy to introduce fresh oxygen, it is more difficult to rid the air of harmful gases, such as carbon dioxide, hydrocarbides, and sulphur dioxide. In face of the difficulty of purification, action is limited in practice to absorbing the carbon dioxide, and introducing oxygen, which is used in the compressed state (see article "Air of the Workroom").

The cleansing of the atmosphere does not give pure air in sufficient quantity, so complete renewal of the interior atmosphere must be sought after. Strictly speaking, this renewal is particularly possible, or, to be more accurate, what is affected is dilution of the harmful substances; in short, it is ventilation on a reduced scale. For this purpose compressed air is used which, in a given quantity, replaces an equal quantity of vitiated air which is driven out by the pressure. This imitation of the chemical composition, and at the same time the hygrometric state of the air.

In order to avoid unnecessary sources of air pollution, electric lighting is used, and it is indispensable at depths exceeding 12 metres. Because of the low height of the compartments, the lights are placed on a level with the eyes; hence, owing to glare, they cause eye troubles. Frosted glass lamps lessen, but do not eliminate, this disadvantage. Indirect lighting should, therefore, be adopted. To diminish surface glare, the walls and ceilings must not be highly polished.

In determining a suitably healthy diet, the crew may be considered as being subject to a moderate amount of work. The problems which arise are mainly concerned with the preparation and preservation of food. In the first place, electric cooking must not use up much power. In consequence, the food should be in forms which allow of easy preparation. But cooking leads to the generation of steam, which increases the humidity of the air. The preservation of the food also is in itself difficult, fresh food being very rapidly decomposed by the gases, the temperature and the humidity. Dried foods also are soon rendered useless. For this reason tinned foods are resorted to, which, however, present two objections: loss in food value and a sensation of emptiness in the stomach. But, after the first day, the appetite flags, and the feeding is even too abundant. A loathing for tinned foods develops, especially for vegetables, hence recourse to a diet which is over-rich and nitrogenous. However, these drawbacks are not serious considering the short duration of this diet. The use of alcoholic liquor is a debatable question. It has been observed that, in Italy, Marsala is more popular than wine. Its moderate use, especially in winter, has been recommended as being more satisfactory than other drinks and stimulants.

From the pathological point of view, attention should be drawn to a state of extreme nervous tension among the personnel. Hence arises the necessity for selecting the men for the service (see article "Compressed Air Work"). During the first few days phenomena analogous to those occurring among divers may develop, i.e. a sensation of acute distress, dizziness, buzzing in the ears and nausea, which, however, rapidly disappear. During submersion and after work, the men have an irresistible need for sleep. Sleep is necessary; for this reason men not on duty are ordered to keep resting, and only to move about when unavoidable.

The study of the chief functions of organic life in submarines has been pursued by Belli, Olivi and Motegi on persons who have been submerged for twenty-four hours. The blood did not show modifications which were either remarkable or persistent in its figured elements or in its haemoglobin content. Spectroscopic examination did not reveal any indication due to the presence in the air of carbon monoxide, dioxide or sulphuretted hydrogen. Breathing increased in frequency and in amplitude; carbon dioxide reached 16 litres an hour. The pulse corresponded with the respiratory changes, and showed symptoms analogous to those of fatigue. However, experience gained during the war has established that permanent injuries occur; thus an increase of blood pressure was found in a large percentage of submarine ratings; these troubles had decreased noticeably six months after the armistice in 1918 (Great Britain).

So far as metabolism is concerned, the researches of Belli and Olivi, apart from a few individual differences, go to prove that it is not influenced by the composition of the air inhaled, and that the balances, thermal, nitrogen, mineral and carbon, are not altered.

No statistics of sickness exist. However, the various occupational troubles to which the crew of submarines are frequently exposed are as follows:
Poisoning by naphtha owing to liberation of gas from the reservoirs during combustion; and by arsine retted hydro¬gen in the blood of 30 men asphyxiated by this gas during the war on board submarines. Dudley noted (1916) a large reduction in the number of red corpuscles, and a normal or slightly reduced number of leucocytes. The presence of arsenic in the urine, the hair and the nails was due to the fact that arsenic was an impurity in the sulphuric acid of the accumulators. With the acid eliminated, fresh cases of poisoning occurred; it was then found that the lead plates of the accumulators contained 0.2 per cent. arsenic. Ear trouble arises from inequalities of pressure. Respiratory affections may result from inadequate ventilation and the inhalation of irritating gases. Dermatitis may be due to naphtha, etc. Conjunctivitis is due to exposure to gases and vapours (McDowell, 1917). Various nervous troubles occur, such as claustrophobia.

But the characteristic occupational disease of the personnel of submarines is represented by asthenopia due to the use of the periscope. The ocular troubles are caused by one-eyed vision, which calls for an effort of accommodation, and is carried out in an inconvenient position. To these factors may be added inefficient and imperfect functioning of the instrument, due to faults in construction and focussing errors, defective illumination and, finally, the visual defects of the observer. The sun, when high up above the horizon, produces a strong, luminous intensity, which affects the sight, and protection of the eye with red or orange glass is essential.

In order to reduce these visual troubles to a minimum, normal vision among the personnel must be a condition of service; a comfortable position must be arranged opposite the eye-piece; and the eye must be protected from the glare of adjacent lights; the lenses must be without spherical or chromatic flaws; and, in order to prevent ocular fatigue, the observer must not be allowed to close the inactive eye. There exists at the present time a special device which allows the inactive eye to be kept at rest, and at the same time protects both eyes from the harmful effect of adjacent lights.

Finally, it should be sufficient to keep in mind the following additional dangers: the impossibility of coming to the surface again after any accident to machinery; gas explosion due to hydrocarbides and air, and to oxygen and hydrogen given off from the accumulators; the cutting off of reservoirs of compressed air; and collisions.

**Bibliography**


Prof. C. M. Belli (Naples).

**Sugar (Sugar-Refining Industry)**


Crystallised sugar, described by chemists as "saccharose," is extracted from a certain number of vegetables or plants growing either in warm climates or in temperate zones, as sugar cane, sugar maple, several kinds of palms, beetroot, etc.

**Beet Sugar**

Beetroot is cultivated principally in Europe. The root is gathered from the end of September to November, then treated locally in factories which have increased so much in importance that 3 to 4 million roots can easily be dealt with in a day. This manufacture is carried out in Austria, Belgium, in the north of France, Hungary, Italy, Holland, Prussia, Saxony, in the south-west of Russia and now in Great Britain.

**Industrial Processes**

The manufacture of beet sugar comprises:

- The reception, weighing and washing of the beets;
- Extraction of the juice;
Defecation; Clarification; Evaporation and crystallisation.

These operations are carried out immediately after the collection of the beets which are treated rapidly in order to lose as little as possible of the sugar contained in the root of the plant. When the stock of beets gathered over an area more or less widespread around the factory becomes exhausted the manufacture properly so-called ceases. This represents two or three months' activity for the factory, the period being called a "campaign".

The sugar leaving the factories is called crystallised sugar. It can be used as it is, but generally it is remelted and refined to be more saleable either as loaf sugar or in pieces. This is effected in other factories called refineries which work all the year round.

Washing the beets. — The reception of the beets takes place either in a railway siding or by a canal or river quay. They are received in such numbers as to provide the necessary complement, and no more, of roots that can be treated without involving much storage in heaps, cellars or silos. Communicating with the beet bin or cellar is the hydraulic carrier which, in its simplest form, consists of a canal in which the water travels in a direction opposite to that of the roots. In the course of this circulation they undergo a preliminary cleaning by which they lose part of the earth clinging to them and some of the leaves and rootlets. The canal ends in the washing machine proper, consisting of an apparatus known under the name of beet washer, which is also provided with a stone catcher.

The washing water constitutes an important part of the residuary effluent from a sugar factory.

Extraction of the juice. — On leaving the washer the beet is sliced into very fine flakes called "slices" or "chips (cossettes)", which are automatically led into cylindrical cast-iron vessels arranged vertically the one beside the other or in a circle. These vessels communicate with each other in such a way that the sugar in the slices is extracted methodically. The pure water at about 80° C. enters the cylinder containing the slices that have already been subjected to the solvent action of waters less and less charged with sugar, while the richest water enters into contact with the fresh slices.

The process of dissolving the sugar contained in the slices is called "diffusion" and the whole series of apparatus in which it takes place is called a "battery". A re-heater is attached to each battery with the object of giving to the water, increasingly rich in sugar, a temperature facilitating exhaustion of the slices. The cylinders of the re-heater are connected by tubes provided with valves. Manholes allow of introduction of fresh slices above the cylinders and their removal from below.

The slices are thus brought nine times into contact with water free from sugar and the juice, having passed through these diffusers supplied with fresh slices, is ready for defecation.

According as the batteries are arranged the progress of the process of diffusion may be different, but the principle is the same: exhausting the slices, by water less and less rich. Displacement of the liquid more and more richly charged with sugar is assured by hydrostatic pressure.

In some of the annexes of sugar factories called "juiceries" the equipment consists of only a washer, a beet slicer and a diffusion battery. The juice so obtained, to which a little limewater is added, is sent to the central factory through an underground channel. These "juiceries" increase the area and capacity of the sugar factories and obviate transport difficulties.

Defecation. — The juice leaving the diffusion battery contains not only sugar, but also nitrogenous and mineral matters that require to be eliminated before concentration of the liquor to extract the sugar. This process is effected by means of milk of lime and precipitation of the lime by carbonic acid gas. This is known as defecation.

The way in which the lime is added and its treatment by carbonic acid may be different. It may be added either separately or simultaneously, the latter being the more usual of the two methods.

In the lower portion of the tank used for defecation are openings by which the carbonic acid enters, forced in by a gas pump and a steam coil intended to heat the juice in course of rectification. The carbonic acid gas tank has a hood for carrying off the gas and vapour given off during the process. Defecation comprises generally two successive operations.

In the first carbonation the juice in the tank with the milk of lime added is brought to a temperature of about 30° C. On introduction of the carbonic
acid gas bubbles immediately give rise to an abundant frothing which is kept down by means of wood shavings or of a steam blower, or by pouring a greasy liquid on the surface. The temperature is raised to 60° or 70°, the production of carbonic acid gas being continued at the same time. When the process is considered to be finished the addition of gas is stopped and the juice is boiled for some minutes. The cloudy liquid thus obtained is pumped into a settling tank to be decanted. The solid particles made up of the carbonate of lime and holding some foreign matter collect at the bottom of the tank. The juice passes on to the second carbonation, while the deposit goes to the filter presses.

The second carbonation is done in the same way as the first, but carbonic acid gas is passed in until the whole of the lime is precipitated. The juice is carried to the boil. The separation takes place in a settling tank. The deposit passes to the filter presses and the juice to be clarified.

Preparation of the lime and carbonic acid. — The lime used for defecation is always prepared in the factory, using a lime as pure as possible, and for heating the furnace washed coke containing neither sulphur or sulphide is employed. The lime solftn is surmounted by a dome connected with a cast iron duct along which carbonic acid gas is sucked by a pump and forced into the defecation tanks. Before reaching the tanks it is purified and cooled in a gas washing apparatus in compartments.

Filter presses. — Whatever the method employed for defecation, the formation of deposit holding considerable quantities of sugar is attained. And it is the same with the scum. Both are sent to filter presses in order to extract from them the juice they contained and this is returned to slake the lime for defecation. The cake is used as manure.

Pulp. — The pulp is made up of the exhausted slices. Generally it is sold to farmers for cattle food and can be kept in silos.

Clarification. — After defecation, sometimes the juice still contains some foreign organic matter, and substances turning a brown colour on contact with air. Use has been made of a certain number of substances for clarification such as oxalic acid, phosphoric acid, sulphurous anhydride and animal black. Of all these, however, only sulphurous anhydride is still used, and that only occasionally, in the processes of defecation because of improved methods of carbonation and defecation.

Sulphurous anhydride not only precipitates the proteid matters and hinders secondary fermentations, but it prevents very largely the change of colours on contact with air, and ensures the fluidity of the juice. Its use depends on a number of factors which it is not necessary to go into here.

Evaporation. — The clarified and filtered juice must be concentrated in order to effect crystallisation of the sugar. It is first converted into syrup by evaporation of about half of its water; then after a fresh clarification it is again concentrated to the point where crystallisation occurs.

The process is carried out by means of evaporation under a vacuum in apparatus generally consisting of three vertical vacuum pans placed near one another and in communication. In the first evaporator the atmospheric pressure is reduced one quarter, and the steam which escapes during the evaporation serves to heat the juice contained in the second evaporator where the concentration continues, thanks to a still higher reduction in the pressure. At last the juice passes into the third evaporator, where the concentration is achieved by a boiler set up by the steam which has escaped from the second evaporator and by a still higher diminution of the pressure. On leaving the last evaporator the juice records from 25° to 26° B. It is syrup.

Boiling. — This process, which has for its object the transformation of the syrup into a thick liquid, in which crystals of sugar can form, is called boiling. It is carried out in vacuum pans of a particular pattern. When the syrup has reached the desired degree of concentration, it is removed from the vacuum pan and a part of the mass on cooling crystallises out. This is "boiling to string proof". Generally the process is so managed that crystallisation takes place in the vacuum pan itself; this is "boiling to grain".

When the boiling is finished the pan is emptied and cleaned by a steam jet. The mass is led into crystallisers.

Centrifugation. — It is not possible to extract in a single operation all the sugar contained in the syrup. The mass placed in the centrifugals yields first a part of its sugar (first product).
The syrup thus obtained is sent to be reboiled and a fresh quantity of sugar is obtained called second product. In this case the apparatus for crystallising is rather different from those used for the first boiling. They have to be kept in a place where the temperature remains from 35 to 40° C.

The syrup coming from this second operation, again boiled and crystallised in the same warm place, yields sugar spoken of as the third product. The crystallisation for this third operation being very much slower, the centrifugation cannot take place until four or five months after the boiling.

The syrup withdrawn from this last centrifugation contains all the foreign matter which the processes of purification have not been able to remove, and they are highly coloured. They constitute the molasses.

In large modern sugar factories the proportion of sugar extracted from the first centrifugation has been greatly increased, so much so as, if not to abolish completely the second stages, at any rate the third.

Treatment of the molasses.—The molasses after centrifugation still contain important quantities of sugar which can be utilised in three separate ways: (1) mixed with forage it makes a rich cattle food; (2) sent to undergo fermentation for the production of alcohol; or (3) treated in such a way as to extract the sugar which it contains. It is this last process which is carried out in special establishments, technically independent of the sugar factories and known under the name of "desugaration factories".

The separation of this sugar contained in the molasses can be done in three ways, all three based on the property possessed by sugar of combining with alkaline earths to constitute distinct salts — sucrate of lime, sucrate of strontium and sucrate of barium, which are soluble, and from them the sugar is easily obtained by precipitating the base. The process with barium, yielding a product of great purity, is only used in Canada and Italy where the oxide of barium is procurable at a non-prohibitive price; that with strontium has been given up as too expensive, but that with sucrate of lime is employed to-day, especially in the United States, as the best method of separating part of the sugar in the molasses.

On leaving the vacuum pan the boiled mass is sent to the mixer and then to the centrifuges, where the centrifuged mass is "clear"ed " in 4 to 6 minutes (i.e. washed with a stream of water) and freed of the molasses impregnating it.

This clearing with water is followed by a clearing with steam, its object being to finish the cleaning of the crystals and to dry them.

By the alternating processes of clearing, centrifugation, boiling and crystallisation, products of the first, second and third order are obtained.

The industry limits itself in general to the production of sugar of the first product and is diminishing considerably work in the centrifuging room, which is very trying because of the heat and humidity.

**Cane Sugar**

The manufacture of sugar from cane differs only slightly from that of beet sugar except in regard to the extraction of the juice. The raw material consists of the stalk of a plant growing in the hottest climates of the globe; it requires, therefore, to be treated as rapidly as possible to avoid loss of sugar. This treatment takes place by crushing and expression in mills where the canes are crushed by fluted cylinders. The juice resulting from this first operation is called sugar juice. It is treated, like the beet juice, by lime to take out the impurities which are similar, though not of exactly the same nature. After carbonatation comes evaporation and crystallisation, just as in the case of beet sugar. The dangers from ill-guarded machinery are the same, as are also the hygienic measures necessary, such as cleanliness and ventilation.

**Maple Sugar, Date Palm, Sorgum Grass**

Industrially speaking, the preparation of maple sugar, palm sugar or sorgum grass sugar has very little importance.

**Sugar Refining**

Cane sugar and beet sugar leave the factory in the form of crystals which do not generally as such come on the market. They require to be refined, that is, purified afresh and changed into an amorphous crystalline mass which is subsequently sold in pieces. For refining, the same processes are

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1 It should be remembered in this connexion that ankylostomiasis is very widespread among those employed in the cultivation of sugar cane at Porto Rico, in British Guiana, and especially in Dutch Guiana. The malady also occurs among the cultivators of sugar and tea in Natal.
workrooms are low and natural light-develop vertically rather than horizontally. Establishments, they have had to situated in towns and are very important. Some underwent rapid development — some in ports, others in large centres of population or near the place of manufacture.

As the majority of these factories are situated in towns and are very important establishments, they have had to develop vertically rather than horizontally. The result has been that the workshops are low and natural lighting is poor, obstructed as it is by neighbouring buildings.

The crystallised sugar is melted, clarified, filtered, boiled and submitted to crystallisation as in the sugar factories, but with some difference. A characteristic feature of the processes is the moist heat in which they have to be carried on, not only in winter, but also in summer. Molasses are, as in the factories, the residue of the manufacture and are utilised as has been already described.

After melting, the sugar is subjected to a first process of filtration to intercept the insoluble portions consisting of the debris of cellulose, and fibres mixed with the crystals on their removal from the wrappings. Another filtration takes place through granular animal charcoal. The use of this substance, made sometimes in the refinery, deserves quite special attention because it raises a thick black cloud in the room which prevents one seeing because it raises a thick black cloud in the room which prevents one seeing. According to Wilson (1920), the work of filling the filters with animal charcoal is work so dirty and unpleasant that the workmen only do it because they are well paid. On entering the chamber they cover their head with sacking and work under very unpleasant conditions and in the dark. Some English refineries have adopted mechanical means allowing the distribution of the animal charcoal to be regulated and making entry by workmen unnecessary. In some cases the filtration is worked from below upwards instead of from above downwards; the liquid is thus distributed more regularly. The revivification of the animal black is a source of vapours and bad-smelling and injurious gas, as it is first treated with hydrochloric acid, and, if necessary, with a hot solution of soda. The wet black mass is allowed to ferment (an alcoholic fermentation occurs first, then an acid and finally a putrescent); it is then washed with water, treated with steam and dried by calcining it in special furnaces.

The boiled syrup may be cooled in moulds either conical (loaves) or parallelepipeds (plaques). The shapes cut up into bits (sawing) in the well-known shape of small parallelepipeds are placed in boxes. The sugary dust is agglomerated by means of sugar syrup and broken afresh. (For candy sugar, see article “Confectioners and Pastrycooks”.)

Dangers

Among the injurious factors are the high temperatures prevailing in the different parts of the factory, the high degree of humidity, the number of substances used or given off in the different processes either in the form of gas (carbon dioxide, sulphurous anhydride, hydrogen sulphide, fumes of hydrochloric acid, evil smelling gases, etc.) or as dust (lime, strontium, sugar, etc.).

Statistics do not show the manufacture to be particularly unhealthy or dangerous; but that perhaps is owing less to the relatively small number of specific accidents or effect on the health observed than to the fact that it is an industry only in operation, except as regards certain departments, for a short time.

The workmen employed in washing the beet are exposed to the weather. It would be well if the washery were under cover. The principal accident to be feared is the fall of a workman into the beet washer along which the beet is conveyed by an Archimedean screw, or the accidental starting of the washer and stone catcher when a workman is busy inside. It might be thought that such accidents would be rare because they are easily avoidable, and similarly those which might happen when workmen are engaged on or are cleaning the elevators and travelling bands while they are in motion, but one of the chief dangers in the industry results from the fact that, no special knowledge being required, the workmen are generally agricultural labourers, employed by the factory during the autumn months, at a time when other work on the land, the plucking of beet excepted, is slack.
Such people are little accustomed to machinery and are naturally more liable to fall victims to accidents. The overcrowding, too, of that part of the works where the beet is received, the constant vehicular movement, motor and horse-driven, and the insufficiency of lighting at night must also be taken into account.

The extraction of sugar by diffusion does not create any special dangers except for the workmen whose duty it is to clean out the diffusers, because while opening up the apparatus they may be exposed to inhalation of gas given off during the operation (hydrogen, carbon dioxide, and occasionally other gases). Another danger to inattentive and unskilled workers exists in the machinery. There is also the danger of burns from steam or from the hot pipes present in all the workrooms. Finally, after the stoppage of the diffusion, there is an accumulation of carbonic acid gas in the apparatus and the foreman of the battery must be careful to clean the diffusers out frequently.

Accidents in carbonatation are due to the workmen entering the tanks to repair or clean them without taking care beforehand to see that the taps and valves admitting gas or steam are properly closed; or without having ascertained whether any carbonic acid gas remains behind at the bottom of the tank.

Mention also has been made of explosions caused by approaching the apparatus for evaporating or for the third product with a naked flame after cleaning them. It is known that in spite of carbonatation carefully carried out some lime always remains in the juice in the form of organic salts. During evaporation the salts become deposited on the internal walls of the apparatus which require to be frequently cleaned. For cleaning an acid is used liberating fumes which, mixed with air, may form an explosive mixture. Causes of poisoning are ammonia, ammonium cyanide, chlorine, alcohol vapours, etc. Similarly there is danger to the workmen employed at the lime kilns because of the carbon dioxide escaping at leakages and accumulating inside the apparatus and certain furnaces (see article "Lime"). The same remarks apply to the workrooms where clarification by sulphurous anhydride takes place. In the room for the third product and the evaporators, the temperature and relative humidity are high, but it is in the centrifugalising room and the room containing the evaporating pans that this heat and humidity reach temperatures that have long attracted the attention of hygienists (see article "Hot and Moist Air"). These rooms are veritable thermostats, the object being not to allow the temperature of the boiling mass to fall too rapidly and get below 40° C. Consequently their unhealthiness is due to the following conditions: as little renewal of the air as possible; very high temperature; high degree of humidity; unpleasant smell; an atmosphere rich in micro-organisms.

The danger of infection is especially one closely related to the presence of micro-organisms in the air, which find in such an atmosphere the best conditions for their development.

Safety and health precautions in the refineries may be summed up in the same way as has been done for the factories. Control of the heat, however, is even more difficult than in the latter as can readily be understood after what has just been said; the ceilings are generally low and work is continuous throughout the year. Temperatures of 25°, 30°, and 35° C. and even higher are recorded in the rooms where clarification, centrifuging and crystallisation are done, with a relative humidity of 80° to 90° per cent. On the other hand, in the smaller workrooms there is risk of explosion when the dust comes into contact with a naked flame.

Finally, as the refineries must have quantities of crystallised sugar so as to be fully employed and must get them when they can, some have very large warehouses where sacks of sugar are piled one on top of the other to a great height. Handling these sacks not unfrequently causes serious accidents either from falling sacks or mishandling of the lifting machinery employed.

Pathology

The statistics of the Leipzig Local Sick Insurance funds show the morbidity of the sugar industry to be very high. The number of sick days is 69 per cent, higher than the average; accidents and respiratory diseases are two and a half times higher than the normal, and diseases of the digestive tract 30 per cent, higher, while rheumatism shows a percentage of 70 per cent, above the average. These figures, however, refer to a relatively small number of persons (40-50) and Lehmann is of opinion that the high morbidity noted might be explained by the fact that the manufacture of sugar is limited to unskilled persons and is carried out during the cold season of
the year. In refineries working the whole year round conditions are considerably better. A similar condition has been noted in other countries (France, Italy, Russia, etc.).

The high temperature is the cause of headache, heat stroke, intense thirst, and sometimes fainting. The workman drinks huge quantities of water and becomes the victim of digestive ailments. These very high temperatures may be avoided thanks to the installation of adequate systems of ventilation.

Saizeff (1927) found, at the end of a sugar season, rheumatism (24 per cent.), furonculosis (20 per cent.), acute bronchitis and other illnesses due to chills; and Chafanow (1927) loss of weight through evaporation of water due to high temperatures. Malaise and high temperature are present also in the process of clearing, especially if centrifugals and mixers are installed in the same room. They favour naturally the contraction of chills, rheumatism and respiratory affections.

On the subject of if and how sugar dust acts on the respiratory tract opinion is divided. Some writers (French) think that 10 per cent. of the refiners are subject to tuberculosis, while the majority take the view that it has no specific action in the lungs. There are no two opinions as to its effect on the teeth (see later).

According to certain Italian writers, tuberculosis is said to be only slightly prevalent among refiners working under good conditions. Evidently one cannot generalise about such a point as local conditions in different countries vary so much.

A certain number of accidents from the centrifuge have been reported, involving fracture of the outer casing owing to faulty charging or excessive speed. But what characterises the rooms in which the centrifugals are placed from the point of view of hygiene is a dermatosis attacking all the uncovered parts of the skin, fingers (especially the borders of the nails), hands, forearms, face and neck. The workmen who go down with naked limbs into the molasses tanks are attacked on the arms and legs. The splashes from the boiling sugar get into the cracks on the skin and induce an exudation of serum. Secondary infection follows and the lesions become pustular. Often the dermatosis is favoured by contact with pants saturated with syrup. Those who are employed on sugar in a viscous state, on the molasses of the second product in sugar factories, in centrifuging, or boiling are especially liable. Oliver long ago described a lymphangitis accompanied by discomfort and boils.

The infection seems to be produced at places where the hair follicles are conspicuous; the dry viscous mass when removed pulls out the hairs and pathogenic organisms gain entrance. The malady commences with slight fever, preceded by shivering and feeling of weakness. The healthy skin shows a localised infiltration which, after a few days, takes on all the characters of a very painful boil. Lymphangitis and inflammation of the glands are present and unless lanced the boil bursts of itself with escape of a quantity of pus. Healing is very slow. Sometimes the boils are multiple and they can even unite and cause a condition of cellulitis.

This lesion affects two-thirds of refinery workers employed in the crystallisation of the products of the second product and especially those engaged on it for the first time. Curiously enough, this affection tends to become less and less frequent after the first year and only attacks those working in successive "campaigns".

Gardenghi has shown that the micro-organisms which cause the infection (staphylococcus pyogenes albus, and sometimes aureus also) can be found in the boiled masses in the crystallising vats. The conditions of the medium naturally favour their development and Gardenghi is of opinion that the non-sugar elements contained in the secondary substances make the skin very susceptible to the action of the pyogenic organism in facilitating and exaggerating their effects. The heat and humidity also play an important part, because they tend to macerate the skin and so favour the action of the micro-organisms.

Nevertheless, cases of lymphangitis not only in the factories, but also in the refineries are becoming rarer and rarer.

The Medical Inspector of Factories for Great Britain, in his report for the year 1922, has some interesting observations on a dermatosis peculiar to refineries. Thus, in two factories employing more than 4,000 persons 12 cases had been noted in five years. The parts affected were the hands in 8 cases, the hands and arms in 1, arms and face in 2, both legs in 1. Duration of employment before the malady appeared varied — in 2 cases it was six months, in a week only. 1 at the end of one year, 2 between one and two years, 2 between two and five
years, 2 after five years, and 1 after 34 years. The dermatitis shows itself generally in the interdigital spaces as a scaly rash and extends from there to the back of the hand. Later these scales weep, but the affection rarely looks like a genuine eczema.

The statistics published by the British authorities of food-poisoning contain the following figures for dermatitis reported during the period 1928-1930: cases due to sugar, 187; cases among confectioners, 93; cases among sugar refiners, 37.

In refineries attention must similarly be paid to sugar breaking. All the time the workmen are coming into contact with lumps of powdered sugar and some of the latter must get into the air. Contact with the lumps, it has been found, abrades the epidermis of the finger-tips, which becomes extremely sensitive to the pricks from the sharp points of the crystals. This lesion is also very common among sawyers and packers of sugar.

Although it is difficult to show that sugar has a specific action on the skin the facts stated give support to the view. Bridge considers that the sugar itself plays a role in producing the condition. Once affected, a second attack easily follows on contact with sugar. In some factories workmen who have had two attacks are transferred to other work. This danger, which is really not very formidable, can easily be combated by attention to cleanliness (washing accommodation, baths, etc.).

Deposition of sugar on the teeth and gums, unless removed by frequent cleaning, favours fermentation processes and loss of the teeth. Dental caries often shows itself after 1, 2, or 3 years; in those who observe good dental hygiene after 4 to 11 years, and in those who have a very good set of teeth in 10 to 14 years. According to observations of Koelsch and Misch among persons of 40 years of age employed in sugar factories, only 6.7 per cent. sound teeth out of 32 were found. Kuhnert, in 1901, stated that among all persons of 25 to 28 years of age coming into contact with sugar only 40 per cent. of the teeth were sound, while the percentage fell to 21.2 for persons of 40 years of age. Friedländer (1921) considers that the caries can only be caused by the sugar dust and not by sugar consumed as food. Examination of 1,208 persons whose mean age was 34, and who had been for 14 years on an average in contact with sugar, enabled him to say that (out of a potential total of 38,121) the teeth in 43.3 per cent. of the cases were sound, in 3.5 stopped and in 53.3 per cent. defective (and of these 41.8 had been extracted, 10 fallen out and 7.2 were carious).

Gerbis in 1923 was able to examine 300 men in sugar factories. The cases with earliest development were those of a man aged 51 employed for 8 months in crushing sugar and a girl working for 5 months in the section for fondants. Generally caries begins about a year after commencing work, whilst tartar appears within a few months. Caries and loss of the incisors were noted by Gerbis in 6.5 per cent. of persons within less than a year’s employment, in 25.5 per cent. between 1 and 3 years, in 46.8 per cent. between 3 to 10 years and in 25.42 per cent. after more than 10 years. In the last group 44.58 per cent. had a denture either completely ruined or lost. Not one had an intact set.

Watré (1927) considers, in the light of his experience, that the dental lesions appear after six years’ work and that sugar dust acts mechanically by causing gingivitis.

In 1921 eye troubles (conjunctivitis, superficial keratitis) due to the pollution of the washing waters by sulphur-etched hydrogen were found in 1921 in the best-washing department of a Dutch sugar factory.

Thiele (1928) also found keratitis, which he ascribed to sulphur-etched hydrogen, in three sugar-factory workers.

Three cases of poisoning, of which two were fatal, in a sucrose works employing the baryta process were ascribed (Leclercq and Vallée, 1926) to the gases given off by the electric furnaces for the regeneration of barium carbonate and containing carbon monoxide, amines, hydrocyanic acid, ammonium cyanide, various hydro-carbons, etc. Jacobi (1927) reported three cases of carbon monoxide poisoning.

Saizeff (1927) found in sucrose works caustic burns on the hands and conjunctivitis due to lime dust. The workers who were unaffected at the beginning of the season were all suffering from conjunctivitis at the end (two months later).

Hygiene

The most important measure is to see that the floor is impermeable and smooth and channelled so as to allow the water to run off. The walls and ceilings should be impermeable and frequently washed; cleanliness should be meticulous, and accumulation of matter capable of fermenting should be prohibited. Apparatus should be arranged on a careful plan and precau-
tions should be taken to prevent the escape of gas and steam from furnaces, tanks and evaporators. The chimney stack should be a high one. Manual labour should be, as far as possible, replaced by automatic machinery.

In very hot and humid places work should be done mechanically as far as possible; there should be artificial electric lighting and alternation of employment so as to limit the length of time spent in these rooms; a place for refreshment, which might usefully be placed near by, should be provided, separation of the centrifuge rooms with localised ventilation of each one; ample air space; propulsion of dry hot air; energetic extraction of the hot saturated air; fireproof covering of the steam pipes; removal of the mixers from the centrifugal as which should, if necessary, be provided with constant cleaning should be effected with hot dry air by mixing beforehand saturated with superheated steam. From the hygienic point of view, clarification by water is much to be preferred to that by steam (and from the economic point of view also).

The water from condensations should be considered animal blood regenerated by mechanical means. If this is not practicable, the filters should be charged in such a way as not to expose the workers to its inhalation.

The immediate surroundings of the lime kilns and the sides of the piping leading the carbonic acid gas to the tanks should be arranged so that they can be watched easily and no one should be allowed near them except workmen whose duty it is to look after the furnace. The same remarks apply to the sulphiting plant.

The cleaning of the boilers, tanks and vessels in which gas might accumulate should only be undertaken after ensuring complete ventilation and under the direction of a foreman.

Measures for the temporary storing, transport, and disposal of residues of all kinds should be adopted. Sugar factories use enormous quantities of water in the different processes. Thus 1,000 quintals of beet require about 700 or 800 cubic metres of water.

The water from washing the diffusers, pulp presses, and, in less degree, that from washing the beet, is very liable to ferment. The former contain about 5 parts per 1,000 of organic matter in suspension and 6 to 8 per 1,000 in solution as well as 3 per 1,000 of sugar. These fermentable waters give off a very disagreeable smell and statutory provision is made in all countries to prevent their passage into streams. The condensing water is relatively free from risk and still less so the washing water.

The problem of the purification of these waters has always been a matter of great difficulty and they cannot all be treated in one and the same way, as regard has to be paid to the kind and quantity of the water coming from the different sections of the factory.

Chemical treatment (with lime, oxide or sulphate of iron) is expensive and insufficient; mechanical filtration only represents a partial solution of the problem.

Biological treatment, preceded by filtration and aeration, gives good results, but eliminates only 40-70 per cent. of the organic matters. The problem of complete purification of the sugary waters therefore still awaits solution. (See also report of the British Ministry of Agriculture and Fisheries, published in 1928.)

Separate treatment of the residuary waters of the different departments can be tried. Thus, e.g., clarification of the waters for washing and extraction of the juice, containing earth, roots and debris of beet, sugar, and salts, can be effected by sedimentation and repeated filtration over sand and cinders. The substances contained in the water can also be decomposed by reagents such as chloride of iron, alum, permanganate of potassium, with production of water capable of being sent again to the factory.

The waters from treatment by charcoal containing ferments, alkalis, albuminous matters, etc., can be filtered through wood charcoal and treated by acid magnesium, phosphate and a basic iron salt. The best results, however, are those from biological treatment combined with some other process, either mechanical or chemical.

For personal hygiene see that article.

Lymphangitis has disappeared wherever the workmen are able to avoid frequent handling of the viscous sugary masses, and where douche baths and means of personal cleanliness have been provided. Where it has shown itself, frequent washing with antiseptic lotion suffices to ameliorate the condition. Strong workmen with healthy skins whose sweat glands function normally but not to excess should be selected, and those with heart disease and alcoholic subjects excluded. Lastly, it should be added that in many of the sugar factories in country districts some of the workers are strangers to the district and occupy sheds. Such sheds must be kept clean and in good sanitary condition.
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Special Regulations have been issued in Germany (24 Nov. 1911) on the employment of women and young persons in sugar factories and refineries in Austria (28 Aug. 1911, No. 142), in Yugoslavia (25 Oct. 1921, as to health and safety measures in such undertakings), in Belgium (Royal Order of 4 October 1923 concerning the physical purification of the residuary waters), and in Czechoslovakia.

Regulations issued by the Austrian Ministry of Commerce lay down the measures for the prevention of accidents during the reception and washing of beetroot (paras. 2 and 3), diffusion (para. 4), carbonatation and evaporation (para. 5). In this paragraph are laid down the measures necessary for preventing accidents in the cleaning of evaporators with vertical pipes and adoption of means for closing the pipes for steam, carbon dioxide, and juices, is required. Para. 6 deals with the prevention of accidents from centrifuge machines; para. 7 with the breaking of sugar (press guards, circular saws, etc.); para. 8 with the preparation of the lime (perfect tightness of the apparatus, exhaust ventilation for the removal of dust, etc., are required); para. 9 with steam apparatus. Dangerous operations are dealt with in para. 10 (which prohibits descent into tanks or vessels which might contain injurious gases before the absence of such gas has been ascertained; if it is not absent they must be ventilated by washing with water or steam or by blowing air in, etc.). Directions are given for arranging the piles of sacks in stores. Cleaning and repairing the apparatus is dealt with in paras. 11; making the lime in para. 12 (in addition to accident prevention it prohibits the use of the store from which the lime is withdrawn as a sleeping place). The work of diffusion and evaporation are the subject of para. 13 (prohibiting descent into the molasses tanks, carbonatating, evaporating apparatus, especially after they have been cleared with boiling acids; and prescribes constant supervision of the workman employed in cleaning operations). Paras. 14 and 15 treat of the centrifugals and the construction of the ceilings; para. 16 of welfare (sanitary conveniences arranged so that the workers have not to be subjected to great changes of temperature in going to them); drinking water, rest room, washing accommodation, baths, overalls and foot-wear, cloakroom, etc. Protection devices for workers tending, the kilns are described in para. 17. First-aid provision is laid down in paras. 18 and 19, with selection of personal (exclusion of epileptics, deaf persons, the subjects of fainting fits, vertigo and cramp, etc.).

These measures are required also in Yugoslavia (loc. cit. sections 295-313) and in Czechoslovakia (the same as the Austrian Regulations of 1911).

The Netherlands requires notification of dermatitis (eczema) and synovitis of the joints and tendon sheaths and subcutaneous tissue in persons employed in sugar factories and refineries, and of conjunctivitis in beet sugar factories.

Legislation in New Brunswick awards compensation for all illness, the result of infection set up by work with sugar, and in Mexico, for dermatitis among sugar cane gatherers. Great Britain has scheduled among diseases to be treated as accidents for purposes of compensation any dermatitis or ulceration of the skin due to dust and liquids.

Queensland Workers' Accommodation Act, 1925. — Any person engaged in work for the employer (in plantations, sugar factories) shall be given sufficient and comfortable accommodation by the employer free of charge. Such accommodation shall include a bedroom, dining-room, drinking water, shower-baths, etc.

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P. BOULIN
(Lille).
**Sulphate of Soda**
*(Sodium Sulphate)*


**MANUFACTURE**

The manufacture of sodium sulphate (Na₂SO₄) has lost much of its former importance since the Solvay process for the production of soda has taken the place of the Leblanc. Actually its industrial use is limited to the manufacture of glass and, secondarily, that of sodium sulphide. Purified and hydrated it is used as a medicine under the name of Glauber's salts.

The principal process in the manufacture of sodium sulphate is based on the reaction, when hot, of sulphuric acid on sodium chloride.

The reaction takes place in two stages in a special muffle furnace divided into two parts: the pan, which is a large chamber with very thick walls, and the muffle furnace, with its floor constructed of refractory material.

The furnace is charged with common salt and raised to a high temperature, and into it is directed, by a pipe running along the roof of the furnace, the necessary quantity of sulphuric acid at an average temperature of 58° B. and carried to a temperature of near 100° C.

The mixture of sulphuric acid and chloride of sodium is stirred in the pan by means of long iron rakes. When the mass is in a pasty condition, it is pushed through a sliding door into the muffle furnace, where the further reaction is finished.

On leaving the muffle furnace the neutral sulphate of soda is withdrawn, cooled and carried into the storehouse.

While the process is going on, considerable quantities of hydrochloric acid vapours are given off. These gases are carried separately from the pan and muffle furnace into cooling apparatus where they are condensed.

To effect this condensation, two systems are in vogue: the first consists in acid resisting towers packed inside with porous fragments through which the gases rise to be met by a rain of water coming from above. The other process consists in batteries of stoneware Woulfe bottles half filled with water through which the gas bubbles.

A manufacturing process much less in vogue is to use the gas given off in the roasting of pyrites.

The gases, with steam added, pass from above downwards on to the sodium chloride arranged in cast-iron pipes. The HCl solution thus obtained then undergoes suitable precipitation and condensation.

**SOURCES OF DANGER**

Work at the pan and calciner is made peculiarly irksome by reason of the excessive heat given out from the furnaces. And the work of rabbling the mass in the pan, shoving it into the calciner, and finally withdrawing it is rough in the extreme.

The principal nuisance, however, with which we are concerned comes from the escape of gas (see the article "Chlorine") from the furnaces, muffle furnaces, pans, and discharge piping. At the pans the escape is especially pronounced during charging and rabbling the mass subjected to the reaction. It is much richer in hydrochloric acid fumes than that emanating from the second hearth of the furnace, but in the latter the high temperature reached allows sulphuric acid fumes and certain chlorine derivatives of iron and arsenical compounds (arsenious anhydride and arseniurated hydrogen gas) to be given off. They constitute a further risk because of their toxicity. (See the article "Arsenic").

Whenever the charge is withdrawn from the muffle furnace, the sulphate of soda, on cooling, gives off vapour and gases (mostly hydrochloric acid fumes). Analyses made by the Factory Department in Belgium demonstrate that, in the course of cooling, the sulphate of soda undergoes a loss of 0.018 per cent, calculated as hydrochloric acid.

A further nuisance in the manufacture occurs, if effective preventive measures are not taken, from the escape into the surrounding atmosphere of considerable quantities of chlorine gas which has escaped condensation. The destruction thus caused to the vegetation is often considerable and the nuisance created may sometimes make itself felt in an extremely disagreeable manner to the people living in the neighbourhood.

**STATISTICS**

See article "Alkalis".

**HYGIENE**

Mechanical furnaces are in use carrying out the processes of mixing the sodium chloride with sulphuric acid
and rabbling right up to the completion of the reaction. The Mactear furnace is an example based on the action of cast-iron stirrers in mixing automatically the mass subjected to their action.

This removes an important part of the work for the persons employed, because not only is rabbling by pans made unnecessary, but charging and discharging are greatly facilitated. These mechanical means, however, do not eliminate the chlorine emanations, so that the greatest care is necessary in installation, proper maintenance and working of the exhaust ventilation, especially of the hoods above the furnace doors. Escape from joints and fissures in the piping is frequent owing to the high temperature of the gases as they leave the furnaces; they also need constant supervision and frequent luting.

Condensation and cooling of the hydrochloric acid necessitate suitable apparatus if damage to the personnel of the factory and persons living nearby are to be avoided. Cooling, which is effected separately for the gas coming from the pans and from the muffle furnace, takes place, to a slight extent, while the gases pass along in the piping and much more in the thick walled acid-resisting tanks provided with bafflers inside. These tanks (called "douches") are sometimes kept moistened with a little water, which helps to absorb the sulphuric acid vapour without absorbing too much of the hydrochloric acid gas. This latter gas passes then to be condensed in one or other of the two methods already described. As an instance of complete condensation, after cooling, an account in detail of the steps in the process as carried out in works using the tower system is given below.

The hydrochloric acid vapour coming from the cooling tanks is directed into two "scrubbers" constructed of lava and filled with lumps of coke. They come into contact with a spray of water and the gases are thus cooled and wetted, and so condensed for a second time if account is taken of the preliminary cooling carried out in the cooling tanks.

From the scrubbers the hydrochloric acid gases, always kept distinct from their origin, are directed in two groups towards the condensing columns, constructed of lava, 2.20 metres wide and 12.50 metres high. These columns are filled with lumps of coke and a water spray falls constantly on them from above.

The cooled and moistened gases meet this stream of water, take it up greedily and pass into solution of a strength of 16.8° B.

The gases which escape condensation are collected at the upper end of each of the columns, and are carried by stoneware pipes to the bottom of two columns 8.50 metres high, and 1.90 metres wide. These are similarly filled with coke and are subjected to an abundant spray of water; the hydrochloric acid vapours are practically all dissolved; the acidulated water collected at the bottom of the apparatus is only 0.1° B.

These very dilute liquids pass into a drain, where they are mixed with large quantities of water coming from other parts of the factory; they are still further diluted and then mixed with a solution of chloride of lime, which completely neutralises them before their discharge into the river. Finally, traces of hydrochloric acid vapours which may escape from the upper part of the last columns are led into a final chamber analogous to the cooling tanks already described, where they come into contact with a last supply of water and are then discharged into the factory chimney. The quantity of chlorine detected in the smoke drawn from the bottom of the chimney yields, on an average of ten tests, 0.680 grm. of gaseous hydrochloric acid per cubic metre of smoke.

The normal functioning of such a condensing system necessarily depends on the use of a sufficient supply of water to absorb the gases. In certain circumstances there may be important economical advantage in discharging into the atmosphere much hydrochloric acid vapour. In order to prevent such action, which may lead to considerable damage to the neighbourhood, it is advisable to place seals on the water mains in order to prevent any diminution in the amount of the water supply. Further, to make inspection easy, meters with seals attached should be affixed to the water mains.

This double recommendation is of use also in the case where condensation is effected by means of batteries of Woulfe bottles through which the gas is made to bubble.

**Legislation**

Women are excluded from the manufacture of soda salts and sulphate of soda in Argentina, France (where acid vapours are given off), and Switzerland. In Belgium young persons under 16 years of age are prohibited from employment in factories for the manufacture of artificial soda by decomposition of the sulphate, caustic
Soda by means of crude, artificial soda and sulphate of soda. In Spain, lads under 16 years of age and women and girls under 21 are excluded from factories where sulphate of soda is made and in places where acid vapours are given off, from factories where sulphate of soda is made by means of the chloride, and from factories also of sulphide of sodium. In Switzerland and France young persons of less than 18 years are excluded from the manufacture of sulphate of soda by the decomposition of common salt by sulphuric acid and from factories where acid gases are given off. In Italy, boys under 15 and women and girls under 21 years are excluded from the manufacture of sodium salts by means of sulphuric acid, etc.

Invalidity caused by sodium sulphide is treated for compensation purposes in Switzerland as though it were an accident. For hydrochloric acid, etc., see the corresponding articles.

Dr. D. Gilbert
( Brussels).

Sulphur


Sulphur Mines

In Sicily sulphur is found in more or less deep-seated deposits (100-300 metres in depth) of varying richness, and consisting of crystallised or agglomerated sulphur mixed in varying amounts with other calcareous or marlaceous substances of sedimentary origin, which form the gangue. On this mixture depends the richness of the ore utilisable (from 14 to 60 per cent. for industrial purposes).

The first operation in prospecting for sulphur, and which is of no particular importance for the purposes of this article, consists in taking soundings and in excavation effected in regions which geologically would imply the presence of the mineral.

Such excavations consist in the opening up of horizontal galleries or galleries with an incline of 40° provided with the necessary equipment and where a certain depth is reached, with adequate ventilation, which is furnished by means of piping in wood or masonry running along the galleries.

When water is encountered in course of the work it has to be removed by pumping; but where it is present in too great quantities digging is simply abandoned.

Another danger is represented by the presence of fire damp or sulphuretted hydrogen likely to give rise to serious accidents in the case of a sudden liberation. Once a fairly rich deposit has been struck, working on a serious scale is commenced: hewing of the ore in the galleries, extraction and transport from the mine to the nearest station.

Extraction

The deposit of sulphur is attacked as far as possible along its whole extent with the double purpose of extracting the sulphur and proceeding with the opening up and eventual development of the mine.

There may therefore possibly exist various working levels separated from each other by deep intervals of 10 metres or so. The work proceeds by exhausting the product, in attacking the rock at various levels from below upwards and filling up the empty spaces as they are found by material brought from outside.

The workers engaged in hewing employ different methods, according to the nature of the rock.

In general, dynamite is used, but with a view to eluding legislative safety provisions the workers at times use a white powder which they themselves prepare with potassium chlorate, flour and sawdust, and which exposes them to very grave danger. The blasting holes are prepared and loaded by the pikemen. At a fixed hour the men who light the fuses, provided with protective apparatus against smoke and explosive gases, set the explosion in train and control its effects.

Once this operation is completed, the pikemen return to the working face and break into pieces the loosened material and prepare it for transport.

In small undertakings the pikemen do both the charging of the blasting holes and the lighting of the fuse.

When the rock is very friable or the ore very rich in sulphur, the hewing is done by hand by means of a pick.

The pick used is usually prism-shaped and very large; it weighs 5 to 7 kg. and is sharpened only on one side. At the base of the prism there is a hole through which a wooden handle is inserted.

Manipulation of the pick involves a shoulder movement, which requires a certain skill and also demands considerable muscular effort.

Continual repetition of these movements leads to emphysema and pneumoconiosis, which are in fact of very frequent incidence amongst pikemen, who are
also exposed to numerous forms of microtraumatism from flying stones, which become detached in great numbers at each blow of the pick on account of the great friability of the rock, thus creating a risk of eye injury, not a rare occurrence. A technopathy of relatively frequent incidence occurring amongst these workers and connected with the use of the pick and the crowbar, which weighs about 10 kg., is a form of dry tenosynovitis, almost invariably localised in the muscle sheaths of the forearm.

The gravest dangers to which workers of this category are exposed are connected with accidental falls of rock, the effects of which extend from simple contusions to complete crushing. Accidents of this kind may affect the hewers when mine explosions occur before or after the moment anticipated. Accidents of this kind are, however, almost always due to lack of care.

Transport of the material got is effected in three stages: (1) from the rock face to the trucks in the transport galleries; (2) from these galleries to the outside, that is to say, to the pit entrance; (3) from the pit entrance to the place of discharge near the foundries. Wherever possible a system of Decauville rails are laid up to the working face and loading of the trucks is effected directly from the heap of hewn material. When loading galleries are situated at a lower level, loading is carried out by means of hoppers.

In other cases, the transport of the ore is effected by porters — known in Sicily as carusi — who carry the material on their backs but only for very short distances, since it is in the interests of the industry to reduce as far as possible the carrying of loads on the back, which is a very costly system. These porters are of various ages, some of them forty years of age or over. At all events, the youngest are always over the age demanded by law, i.e. over fourteen years of age. The weight of the loads carried varies, naturally according to the age and strength of the worker, from 20 to 80 kg. Amongst porters, especially adults, hernia is frequently encountered and likewise deviations of the spinal column (kyphosis and scoliosis). Apart from accidents to which all the workers in the mines are exposed, the porters often suffer from traumatic lesions, due to material which has fallen from the load they are carrying or from that of their comrades.

The trucks, after being loaded, are pushed by hand to the stations, where trains are formed; these latter are then drawn by mules to the shaft cage, which brings them to the surface. The work of the truckmen involves effort required for pushing the trucks, weighing 1,500 kg., an effort which is increased when the mine galleries are not absolutely level or when, as is very often the case, the ground is damp and soft.

Cases of hernia are common amongst these workers, as well as accidents due to collisions of the trucks when riding on these, and when perchance the trucks leave the rails or overturn.

Traumatic lesions amongst porters are fairly rare, and still rarer in mines where the workers carry the material on their back from the working face to the unloading station at the surface, i.e. in small mines of little importance and of relatively slight depth, which are, on the whole, of little interest from the point of view of production. The trucks on their arrival at the surface are received by the workers, and sent for discharge to the neighbourhood of the foundries. This latter stage of transport may be effected by the workers themselves or by animal haulage, or again by mechanical means, more usually when the level of discharge is higher than that of the entrance to the pit.

The work of truck-men at the surface is similar to that of their comrades in the pit, but it has the advantage of being carried out in the open.

Treatment of the Sulphur

The last phase of manipulation is carried out at the surface, where the mineral is submitted to the action of heat (smelting) in order to free the sulphur from the gangue which surrounds it. This operation is effected in Gill furnaces and in so-called calcheroni (Sicily).

The furnaces are composed of a number of small compartments made of masonry, which may communicate with each other in order that a part at least of the heat produced in the first compartment may be utilised in the others. Loading of these does not involve any manipulation apart from filling the furnaces with the ore when these are lit.

The calcheroni are, on the other hand, vast receptacles constructed of masonry having a circular form, and from 15 to 20 metres in diameter, open at the top and with a hearth, which is constructed with a very strong incline on one side. The charging with ore is effected in a certain order up to the level of the upper edge of the masonry,
the ore which is added thereafter taking on a conical form. The whole is then covered with a layer of foundry residue having a thickness of 10 cm., with a view to preventing contact with the air and allowing only a few holes through which the mass can be fired by means of faggots. In the furnaces above described, as well as in the calcheroni, the agent of combustion which effects smelting is the sulphur itself. A large part of the mineral is therefore lost by transformation into SO₃, which forms a more or less abundant smoke, which becomes disseminated above the mine.

As smelting takes place, the liquid sulphur is recovered from the hearth of the furnace or calcheroni at the foot of the slope, which ends in a special discharge aperture known as the dead space. This aperture is protected by a wall of lesser thickness, and when smelting commences, lasting four to eight days in the case of Gill furnaces and eight to twenty in that of the calcheroni, according to their size, discharge holes for the molten sulphur are effected by means of an iron bar. After smelting has terminated the other workers, scarcaratori (Sicily), after having completely broken down the discharge aperture, loosen and break with a pick the residue (ginesi), which is loaded on to trucks and thrown on to heaps at some distance, being without further value.

For ore which is rich and has a high sulphur content, a combustion process involving the use of coal is resorted to. The ores, which are placed on special trucks with grids, are introduced into cylindrical boilers, the lids of which are bolted on. Steam at a pressure of 4-5 atmospheres, that is to say, a temperature of about 150° C., sufficient to separate the sulphur from the gangue, is passed into the boiler into the centre of the ore. The molten sulphur flows through a hole in a trough, from which it is directed into moulds by means of large ladles.

After this process the ore is not completely exhausted and the residue still contains about 15 per cent. of sulphur. This residue is recovered and submitted to further treatment in Gill furnaces. All the smelting operations are effected under the supervision of workers known as arditori (Sicily), who are subjected during the whole time to the injurious action of sulphur fumes. These cause chronic and extensive bronchial catarrh, with resulting pulmonary emphysema. Amongst old workers cases of atelectasis and pathological derangement of the pulmonary circulation are still met with.

Respiratory lesions are of earlier occurrence and are more usual amongst the scarcaratori, whose work is effected in surroundings charged with hot and bitter dust rich in acid gases from the sulphur, which are liberated during combustion (SO₂ and SO₃).

The transport to the stations of the sulphur melted into block is effected by various means: loaded on donkeys, lorries, carts or again by mechanical means (tramways or overhead rails). Each mine comprises a certain number of auxiliary plants, amongst which an important place is occupied by machinery destined for the production and utilisation of power necessary for the different stages of manufacture.

At the present time, except in rare instances where steam is still used, the mines generally generate the electricity necessary in the thermic stations by means of motors activated by poor gas, heavy oils or naphtha.

Running a mine requires further the assistance of mechanics, electricians, machine-minders, blacksmiths, boilermakers, furnacemen, foundry workers, carpenters, woodworkers, etc., whose work is effected not only at the surface but also in the mine. Mines therefore constitute a highly complicated organisation, to the successful and harmonious working of which numerous categories of workers contribute in various ways and under exposure to various risks, amongst which may be mentioned, as of first importance, account of the risks to which they are continually exposed, timberers — those workers called on to effect their work at the most dangerous points of the galleries and engaged in reinforcing the galleries and workplaces with a view to preventing falls of rock, and securing safety for their comrades engaged in hewing and transport.

**Sources of Danger**

Mining conditions have a predominant characteristic connected with the nature of the ore mined with which the workers are continually brought into contact, in the present instance sulphur. Distinction must further be made between outside work and work in the mine proper, since in the latter special working conditions are encountered.

The temperature in the mine galleries is dependent on a number of factors and principally on the nature of the deposit, on the abundance of ventilation and on the humidity rate.
Underground lighting is always artificial. Use is made of lamps with a free acetylene flame, electric lighting being installed, however, in the transport galleries of certain mines. In very special cases safety lamps are used.

No ocular technopathy like nystagmus has been observed.

Ventilation of mines is almost always effected naturally: the air penetrates into the pits and descending galleries, circulates through all the underground ways and returns to the outside through special piping designated riflessi (Sicily). In very extensive mines there may be several entries for air and several riflessi. Cases of artificial ventilation are rare, but are utilised in certain sections of mines and more frequently at the working face where it is deep and distant and therefore not situated in the path of air circulation.

Even where ventilation is abundant the air of the galleries is exposed to numerous causes of vitiation, e.g. the gaseous derivatives of the sulphur. Amongst these should be mentioned: (a) sulphur dioxide formed during explosions and continuously during combustion of sulphur particles in suspension in the atmosphere which come in contact with the flames of the lamps; (b) sulphuretted hydrogen, which is mixed with the water in the deposit and from which it may easily be liberated; at times it is encountered in pre-existent pockets and it appears to be also produced during processes of maceration and putrefaction of organic substances (wooden supports, refuse) which take place in the subsoil itself; (c) carbon dioxide produced by human respiration, by combustion of acetylene or oil lamps and during explosions. Amongst the derivatives of carbon there are present in large quantities numerous hydrocarbides, amongst which should be mentioned firedamp, which the workers in Sicily call 'antimony', and which is encountered particularly in very deep mines or mines having argilaceous gangue. This gas is sometimes sufficiently abundant to warrant extraction by special piping, at the end of which it remains continually lit like a gas jet.

In the air of the mines and particularly in the dry zones there is found in abundant suspension a type of dust formed during hewing of the ore and all subsequent manipulation during loading of the trucks and during transport. This dust is of the same nature as the ore and likewise the gangue, and is composed of particles

Absolutely dry mines constitute a veritable exception. There is generally a more or less considerable quantity of water which has a twofold origin: by infiltration from the outside through the various geological strata, and secondly the water from the deposit itself, which is, where it is of a calcareous nature, completely immersed in a watery mass more or less considerable in quantity.

Removal of water is one of the most urgent problems in these mines. In certain cases where the formation of the ground permits of it, special galleries are opened to allow of the water running off towards the outside, but as that is not always possible, recourse is had to extraction by means of pumps working without interruption. The flooring of the mine is therefore almost always wet and covered with mud which soils the feet and legs of the workers and often also their hands. This circumstance explains the presence of conditions favourable to the development and propagation of the ankylostoma, and damage is likewise caused by the solution in the water of a derivative of sulphur which Mottura describes as acid sulphate of iron, alumina, and lime, extremely caustic, and liable in strong concentrations to give rise to forms of dermatitis, sometimes even amounting to actual chemical burns.
of lime, clay and silica mixed with particles of sulphur. The latter, by reason of the crystalline form of the product, have rough surfaces and very sharp angles. These characteristics of the air of the galleries become accentuated as greater depths and greater distances from the entrance are reached.

### Pathology

The technopathies from which workers in sulphur mines suffer are dependent on the nature of the ore and on the action which it is capable of exerting in regard to the various chemical states of the system. It is for this reason that respiratory lesions abound. These reactions are due to penetration at each inspiration of a quantity of air containing in variable proportions acid gases from the sulphur and dust. This involves the combined irritant action of the gases with the traumatic action of the dust.

Subsequent to a chronic catarrhal condition, emphysema sets in, consisting in atelectasis and in very advanced cases of pleurisy. Circulatory troubles which never again recovers its former normal state.

Autopsies effected have proved the existence of cases of pneumoconiosis, amongst which predominate anthracosis due to a deposit of particles of carbon formed chiefly during combustion of the lamps. There is more rarely found deposits of sulphur dust designated by Giordano as "theapneumoconiosis".

The data collected in the course of visits made by doctors belonging to the Sicilian Association for the Pre-
vention of Industrial Accidents proved that about 50 per cent. of the workers in these mines suffer from chronic respiratory affections.

Another pathological manifestation consists in a certain degree of anaemia, quite independent of any other precise and specific cause (ankylostomiasis, malaria), but which would appear to be caused by the harmful action of the acid gases of the sulphur and sulphurous products on the red blood cells. This feature is very obvious amongst workers who work continually in mines or parts of mines where the presence of sulphuretted hydrogen is more marked.

Hernia has been met with in the case of about 25 per cent. of the workers.

Eye diseases are confined to chronic forms of conjunctivitis caused and favoured by the irritant action of dusts and gases amongst which a chief place is occupied by sulphuretted hydrogen. These symptoms affect about 20 per cent. of the workers.

Cases of deformation of the thorax and vertebral column (scolioses, lordoses: about 8 per cent. of the workers) are of rarer occurrence. These cases are diminishing now that transport on the worker's back is being replaced by mechanical transport and with the coming into force of the law prohibiting underground work for boys under fourteen years of age.

As regards infectious diseases, it must be stated that tuberculosis is a very rare occurrence amongst sulphur workers, either in visceral or in surgical forms. Cammarata (1923) found skin reaction to tuberculosis positive in a proportion of 95 per cent. amongst thirty sulphur miners.

Malaria is very widespread, and it may be said that a third of the workers have suffered from this disease for a more or less considerable period. The mines are always situated in unhealthy regions. It has further been noted that the anophelles mosquito may, under certain conditions, live and propagate in the mine galleries, thus increasing the possibility of contagion.

Ankylostomiasis is equally very extensive. Very few of the mines, two or three only, are free of it. However, it is a case of individuals suffering not so much from true anaemia as constituting carriers of the germs which are present in a fairly high percentage.

Whilst special reasons exert their effect in favouring the biological capacity of the parasites and at the same time attenuate individual resist-
by bridging short gaps (see article "Dust").

Accidents due to smoke tend to diminish in mines on account of the adoption of adequate means of defence (masks and oxygen apparatus).

Mine explosions may give rise to accidents, but are almost always due to imprudence on the part of the worker. Their effects may be very grave and often the sight is affected.

Inhalations, happily fairly infrequent, of sulphuretted hydrogen are always the consequence of sudden escapes of this gas and give rise to very acute poisoning which almost always ends fatally. In the less serious cases the symptoms disappear very slowly and usually leave poverty of the blood, which is hard to modify even after long delay.

Inhalations of firedamp (called "swallowing antimony" by the workers) may also cause serious cases of poisoning, but the greatest danger resides in combustion of gas and in explosion, since at that moment the flame from the explosion may envelop those workers which it encounters, with consequences rendered still more serious by the fact that the workers work naked or almost naked, thus offering vast surfaces to burns which affect also the mucous membrane of the mouth and the upper respiratory passages.

In certain cases where the volume of the gas is considerable, the galleries act like the tube of a cannon, within which the explosion projects and crushes against the walls the workers found therein.

Accidents due to firedamp therefore affect a large number of workers and are fatal on account of the extent of the burns. Death generally occurs six or seven days after the accident, being due to septicemia with nephritis or peritonitis in the final stages.

**HYGIENE**

In Sicily the mineowners are compelled to belong to the Sicilian Association for the Prevention of Industrial Accidents, which has organised first-aid posts in the mines, certain of which have doctors and nurses in attendance and others only nurses. This association pays for treatment of the victims

**Fig. 152. — An elderly sulphur carrier (Caruso).**
until complete recovery; it calls on the local consulting physicians for treatment for ordinary cases and sends to hospitals or convalescent homes the badly wounded or those having need of special care.

The association has served as a basis for the application of other branches of assistance, principally in the campaign against malaria and ankylostomiasis, a campaign in which the Public Health Department participates very effectively.

All the first-aid posts and all the consulting physicians in the communes are engaged in various ways and in accordance with the possibilities in the anti-malaria campaign, since during the whole year the curative treatment of the diseased is carried on, and during the epidemic season the prophylactic treatment of healthy individuals, as well as defence by means of "small-scale" health measures. It has been found that the extension of these means has resulted in arresting and even completely eliminating malaria in certain mines.

In the campaign against ankylostomiasis those measures are adopted which appear necessary and opportune from time to time. At Caltanissetta a hospital has been erected in which workers from all mines showing definite symptoms of anaemia are treated. Whenever small centres of diffusion become manifest, cleaning up and rendering healthy of the mine is engaged in, detection of the parasite being assured by microscopic examination of the excreta, examination of carriers and finally their disinfection while at work by means of daily thymol treatment combined with disinfection of the underground workings by application of milk of lime prepared on the spot.

The association has been able to constitute a special fund destined for thorough care of cases of hernia, which, on their own request or on that of the doctors concerned, are sent to a hospital, where they undergo adequate surgical treatment. In the principal mines rescue posts are attached to the first-aid posts furnished with accident apparatus, masks for fumes and smoke, electric safety lamps and lamps for measuring firedamp, safety belts, portable telephones and all other apparatus necessary for effecting rescue work or for the execution of work rendered especially dangerous by the presence of irrespirable gases.

This special service works in connection with a central rescue post at Caltanissetta, installed under the aus-

LEGISLATION

In Italy: Act of 30 May 1903, No. 184; Regulations of January 1907, No. 152, dealing with the regulation of mines, quarries and peat pits; Regulations of 3 December 1908, No. 787, on the service of rescue posts for workers in the sulphur mines of Sicily; Regulations of 3 July 1921, No. 1190, on the safety service of workers occupied in sulphur mines in Sicily. As regards work of women and children, the general measures issued for the regulation of work in mines are applicable. Boys under fifteen and women under twenty-one are excluded from grinding and refining of sulphur.

Dr. I. di Giovanni
(Caltanisetta, Sicily).

Sulphur and its Compounds

Sulphur, symbol S, is found in its native state under different forms: in crystals, in a compact amorphous mass, in stalactites, or in pelvulent layers. It is generally extracted from sulphur mines (see above), but in American cokeworks recuperation in a colloidal form of the sulphur contained in the gas has been effected.

In the pure state, sulphur is an element which is yellowish in colour and crystallises in two forms: rhombic and monoclinic. It is practically odourless and insipid; it melts between 114° C. and 115° C. (rhombic sulphur) and 119° C. (monoclinic sulphur). At this temperature it assumes the aspect of a yellow mobile liquid, which towards 250° C. becomes consistent and viscous and of a reddish-brown colour. It re-assumes a fluid form above 300° C. and boils at 445° C., giving off orange-red fumes.

It burns easily in air with an azure flame, liberating an irritant odour of sulphur dioxide. It is insoluble in water, slightly soluble in alcohol, ether and benzine and readily soluble in carbon disulphide.

Sulphur is used in the preparation of sulphuric acid, sulphurous acid, sul-
phites and hyposulphites, carbon disulphide, cinnabar, mosaic gold, artificial ultramarine, and organic sulphur colouring agents; it is likewise employed in vulcanising rubber and gutta-percha, for bleaching (wool, straw, etc.), in preparing cements, in the manufacture of matches, wicks, and inflammable powder, for coating wine or beer casks, etc. It is recommended for impregnation of wood with a view to its conservation, long the manufacture of compressed articles with a basis of cement, wood, cotton, or coke dust. Sulphur enters also into the composition of hardened and waterproofed papers and into that of certain plastic products (plastiline: 23 per cent. of sulphur). In agriculture sulphur is employed for dusting vines, fruit trees, vegetables, etc. Finally, numerous pharmaceutical products have a sulphur basis: ointments, pastes, etc.

Pulverised, sublimated or precipitated sulphur exerts an irritant action on the skin, which in the case of certain predisposed individuals may take the form of eczema (Hesse). In practice, however, affections of this kind are relatively rare. The mechanical action of sulphur on the ocular conjunctivae of agricultural workers, for example, has long been known. Eulenburg (1881) considered that sulphur was capable of causing even a very violent form of the above. Yet whilst Piconveri (quoted by Hirsch) is said to have noted a fairly high number of cases of conjunctivitis caused by sulphur — a fact which was confirmed by Burruano in 1906 — Hirsch (1910) does not claim to have noted any special form of conjunctivitis amongst the miners in the Rhineland.

Amongst the compounds of sulphur may be rapidly summarised sulphate of soda (see that article), sulphate of quinine (see article "Quinine"), and sulphate of nickel (see article "Nickel"); sulphide of ammonia utilised in artistic bronzing (Collis); sulphate of arsenic (see article "Arsenic"), etc., all of which may exert a violent action on the skin, mucous membranes, nails, hair and skin. This action is still more marked in the case of sodium sulphide, which causes erythema, papular and pustulous dermatitis and even ulcerations, at times deep-seated. According to Prosser White, it is more irritant than the chromates. Sulphide of potassium and sodium is very alkaline and causes very serious dermatitis and ulcerations amongst washerwomen who use hot solutions. Sulphide of calcium is also a skin irritant. Sulphate of soda is likewise a skin irritant and may cause dermatis and superficial ulceration. Prosser White has described lesions of this kind amongst women workers engaged in cotton dyeing. Bisulphate of soda, used in the cloth printing and bleaching industry, may also cause cutaneous ulceration amongst workers engaged in attending the colouring baths. Nevertheless, in such cases there must be taken into consideration the joint action of other ingredients utilised in preparing the said baths (lyes, soaps, sulphurous acid, sulphuric acid, etc.).

There should be recorded finally sulphur colouring agents (see article "Dyes"), used in alkaline solutions (carbonate of soda, sodium sulphide), which cause irritation of the skin. Prosser White has reported cases of dermatitis amongst workers who prepare sulphur colours, organic sulphuric acids, sulphonates, etc.

**LEGISLATION**

In **Spain** boys under sixteen and women under twenty-one years of age are excluded from grinding, boiling, and packing of sulphur; in **France**, young persons under eighteen are excluded from the two former processes, where there is liberation of dust; in **Italy**, boys under fifteen and women under twenty-one are excluded from grinding and refining of sulphur.

In **Greece**, boys under sixteen and young women under eighteen years of age are excluded from operations involving contact with sulphur compounds.

In **France**, women and young persons under eighteen years are excluded from workrooms for the roasting of sulphurous ores, but are on the contrary admitted in sulphur works when the gases are condensed and the ore does not contain arsenic.

In **Belgium**, young persons under sixteen years are excluded from the manufacture of sulphates of sulphur and from roasting the manufacture of sulphate of copper by means of the oxide and the carbonate of this metal and of sulphuric acid, from the manufacture of sulphate of zinc by the action of sulphuric acid on this metal, from that of sulphate of iron by the action of sulphuric acid on iron or cast iron, and from the manufacture of sulphones (women under twenty-one). In **Spain**, boys under sixteen and women under twenty-one years are excluded from the manufacture of sulphate of peroxide of iron by means of the oxide of iron and nitric acid (workrooms in which there is liberation of fumes or in which acids are used).

In **France** absolute exclusion of women as well as of young persons under eighteen years is required in the manufacture of sulphate of peroxide of iron by means of the oxide of peroxide of iron and nitric acid (workrooms where fumes are liberated), and from the manufacture of sul-
phate of protoxide of iron by the action of sulphuric acid on iron filings. Women are also excluded from the manufacture of sulphide of sodium.

In Italy, boys under fifteen and women under twenty-one years are excluded from the manufacture of sulphites.

Injuries caused by sulphur are subject to compulsory compensation in New Brunswick (sulphur and its compounds) and in British Columbia (coal mines), and injuries due to chloride of sulphur in Switzerland.

As regards the other compounds, see articles "Sulphur Dioxide", "Sulphuretted Hydrogen", "Toluene" (sulphochloride), "Dimethylsulphate", "Sodium", "Sulphuric Acid", and "Carbon Disulphide".

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Sulphur Dioxide


CHEMISTRY

Sulphur dioxide is a colourless gas of which the formula is SO₂. It has a peculiar irritating and suffocating smell and an acid taste. Its density is 2.86; it is very soluble in water: at 15° C. 43.5 volumes dissolve in 1 volume of water, giving a colourless solution of a density of 1.042 and containing 11.92 per cent. of sulphur dioxide. This solution acts as sulphurous acid (SO₂H), which cannot be isolated. In its gaseous and anhydrous state it does not corrode iron, but a solution of 1 per cent. in water is sufficient to do so.

Sulphur dioxide can under certain conditions be reduced by some bodies (for example, hydrogen); it is still more easily oxidised (see article "Sulphuric Acid"); it acts as a reducing agent; it has decalcifying properties (hence its use in the manufacture of gelatine); and, finally, it has disinfecting properties.

It is used in industry in its gaseous state, or in solution, or as liquefied gas. It is easily obtained in this latter state by compressing purified and dry gas, or freezing at —15° C. It is a colourless liquid, with a pungent smell of a density of 1.44. Each litre gives 500 litres of gas at 0° C. and 760 mm. It boils at —8° C. and produces considerable cold on evaporation. It is stored and transported in iron or steel cylinders which have a resistance of 30 atmospheres, filled in the proportion of one kilogram of liquid sulphurous acid to 0.8 litre of capacity. Glass tubes sealed by flame are also used containing a maximum of 100 grams of sulphur dioxide, three quarter parts filled and transported in wire receptacles protected with "kieselguhr".

MANUFACTURE

The preparation of sulphur dioxide is carried out by (a) the combustion of sulphur, (b) the roasting of sulphides, (c) the combustion of sulphuretted hydrogen, (d) the reduction of sulphates, and (e) recovery from mixed gases.

(a) Combustion of sulphur. — Sulphur is burnt in a current of air upon the floor of special kilns. The operation is carried out slowly and at a relatively low temperature to avoid sublimation of the sulphur, which always occurs with a raised temperature even if cooling apparatus be installed. The necessary air is supplied by fans, by exhaust ventilation, or by pressure.

Numerous types of kiln have been made, some even mechanical, but they are only capable of producing small quantities of sulphur dioxide; large quantities are obtained by roasting pyrites.

The gas on leaving the kilns is cooled and purified. Purification is necessary with a sulphur which is very impure and full of ash dust; it is effected in an apparatus, called a sublimator, consisting of tubes in which the dust is deposited. The cooling takes place in worms of various forms, or in flues. When sulphur dioxide is required to be used in solution the gas is condensed in vessels made of pitch pine, arranged in series, in which the absorbing liquid is placed.

(b) Roasting of sulphides containing 20 to 25 per cent. of sulphur (pyrites): sulphides of iron : blends : sulphides
of zinc). Pyrites arrives usually at the chemical works already pulverised, or else is reduced to the size of bullets which issue in a continuous stream from crushing mills. Some kilns only require a preliminary breaking up of the ore.

The pyrites kilns are constructed on the principle of chambers with five or six partitions arranged in layers varying in shape and disposition. The ore passes from the top to the bottom whilst the gases arising from the hearth circulate from the bottom to the top, or in making sulphate of calcium, which contains from 1 to 2.25 per cent. of dross in a high temperature furnace, further obtained by breaking up the ore. Various processes use these separations, by the combustion of sulphuretted hydrogen.

(c) Combustion of sulphuretted hydrogen. — This gas is a residue from making of soda by the Leblanc process, or is obtained by the reduction of sulphate of calcium, and in making sulphate of ammonia. The combustion is carried out in special kilns with a burner constructed on the Bunsen principle.

(d) Reduction of sulphates. — It is possible to obtain sulphur dioxide which may be used straightway for making sulphuric acid. The sulphates most often used are gypsum and the sulphate of magnesium. The latter is reduced with charcoal at a temperature of 850-950° C. (Griesheim has used this process of making sulphuric acid since 1913.) The liberation of sulphur in the form of a sulphurous gas. The gas so obtained contains from 5 to 6 per cent. of sulphur dioxide. The addition of sulphate of calcium increases the strength of the sulphur dioxide.

(e) Recovery of sulphur dioxide from mixed gases. — It is possible to obtain sulphurous gas by the combustion of products used to purify gases rich in sulphur (purifying materials) or to recover it directly from the mixture of gases. Absorption of the gas by water in washing towers is not good since 1 to 2 per cent. of the sulphur dioxide is not caught. Animal or wood charcoal has a greater absorbing power. Special substances (carboraffin, etc.) are also used.

It is important to remember that the heating of a solution of sulphur with sulphide of carbon gives a gas very strong in sulphur dioxide (75 per cent.).

Liquefied sulphur dioxide is prepared for industrial purposes by the process of Haenisch and Schroeder. The gas obtained from the roasting of pyrites is absorbed in water; the weak solution is strengthened by evaporation. The steam and gas which come off are passed into a drying tower and after complete drying the sulphur dioxide is passed into a compressor, then into a worm where it is retained and liquefied. It then passes into the collecting vessel.

SOURCES OF INTOXICATION

1. During manufacture. — During roasting the workers are continually exposed to the inhalation of small quantities of gas; but the risk is greatest when great quantities of sulphur dioxide are liberated, especially following bad management of the process.

Workers are also possibly exposed to the absorption of arsenical products (arsenious acid) if the pyrites is arsenical (which is often the case). Kobert has shown that the danger lies not only in the inhalation of vapours but also from the clothes becoming impregnated with sulphur dioxide.

During the manufacture of liquefied sulphur dioxide workers are exposed to inhaling the gas which escapes from the apparatus owing to the erosion of the compressor pumps and the receptacles used for transport, which become corroded if the gas is not perfectly anhydrous. A change of temperature may cause the metal receptacles to explode.

2. During its use. — Sulphur dioxide is in frequent use, particularly for the
SULPHUR DIOXIDE

Following processes: its own manufacture and that of sulphuric acid; the manufacture of cellulose, of glue and gelatine from bones (making use of the decalcifying properties of sulphur dioxide); in the conversion of starch into sugar; in extinguishing fires; in dying (using the reducing properties); in bleaching wool, silk, paper pulp, feathers, straw (the hat industry), sponges, gelatine, wax, hair (decoloration and disinfection of white brushes); making use of its decolorising properties. In all these processes sulphur dioxide plays an antichlorine part, that is to say, it neutralises the chlorine used in the preliminary bleaching.

It is also employed for whitening articles of food (maize flour, sugar, etc.) for keeping in good condition fruit, preserves, beer, malt, etc., instead of bisulphite of soda or lime. Its disinfecting properties are used both for the disinfection of boxes used for preserves, or barrels (sulphuring wine casks by matches of sulphur) or buildings and ships (destroying rats): the sterilisation of unfermented wine to insure it keeping, etc.

Sulphur dioxide is used in refrigerating machines by the method of R. Pictet (there is danger when repairs have to be carried out). The use of sulphurous gas in steam engines to increase their power has been recommended.

3. During certain processes. — We are concerned here with those processes in which a liberation of sulphur dioxide occurs: in metallurgy when the ores, as is very usual, contain sulphur at least in the form of impurities (ores of lead, copper, zinc, antimony, arsenic, etc.); this sulphur becomes changed into sulphur dioxide and partially into sulphuric acid as soon as the ore is roasted. It is in addition set free in the manufacture of ultra-marine blue, in some of the pottery processes, in glass making, in making colours obtained from tar, in vulcanising rubber, in refining raw petrol (opening stills), in tanning with chrome, in burning coal containing 0.5 to 2 per cent. of sulphur, etc.

TOXIC ACTION

Sulphur dioxide is an irritant and caustic gas of which the path of entry into the system is by the respiratory passages. Its well-known local action upon the mucous membranes is due, according to Robert and Lehmann, to its transformation into sulphurous acid (H₂SO₃), which becomes oxidised into sulphuric acid (H₂SO₄). On the other hand it might be due to a delayed effect, possibly reflex, or possibly due to some disturbance or modification of the blood. To produce this result the sulphur dioxide must be inhaled in large quantities. Other authors deny this action upon the blood.

Sulphur dioxide, even in weak concentrations, acts very quickly upon the mucous membranes, particularly those of the respiratory system. The strength which can be tolerated has been fixed by Villaret at 0.07 per thousand, but on the other hand it varies with individuals and with the degree to which they have become inured to it. Ogata and Lehmann have shown that for individuals unaccustomed to it a strength of 0.02-0.03 mgr. per thousand is hardly borne, that a strength of 0.04 mgr. causes embarrassment, and that 0.06 mgr. is the greatest strength which can be borne for half an hour without causing injury. Some individuals who are accustomed to it can, on the contrary, stand a strength of 0.1 to 0.12 mgr. per thousand and Lehmann has reported some cases which have tolerated a strength as high as 0.20 mgr. per thousand.

Recently (1924), Kiichiro Muto has demonstrated experimentally arrest of respiration while the heart continued to beat. The smallest fatal dose has been 1.5 per cent. in volume. Electric stimulation shows that the diaphragm reacts. The gas therefore acts directly upon the respiratory centre and paralyses it. On the other hand, according to some experts (Weyl, for example) sulphur dioxide should have beneficial effects owing to its bactericidal power when inhaled for a long period in concentrations which are not too strong. In the opinion of some works managers the men employed in roasting ores rich in sulphur suffer less sickness, and Floret has noticed a great diminution of phthisis among them.

SYMPTOMS

With those who are not accustomed to sulphur dioxide a quite weak concentration of it produces an acid taste in the mouth, an increased flow of saliva and irritation of the nasal, ocular and respiratory mucous membrane, in which area sneezing and attacks of coughing occur which are often spasmodic. If the action is too severe or too prolonged then catarrhal inflammation, either bronchial or pulmonary, occurs and often blood-stained, expectoration. In some cases congestion and pulmonary asthma have
been noticed. Dental lesions do not occur as in the case with industries employing sulphuric or nitric acid. Serious cases caused by this gas are rarely fatal. Further, when the absorption is from high concentrations, digestive troubles (loss of appetite, acid eruptions, and irregular motions) and a livid discoloration of the mucous membranes are noticed.

**DETECTION OF SULPHUR DIOXIDE**

This is done chiefly by the smell or preferably by chemical titration (process of Lehmann with iodine and hyposulphite of soda). In the process of Lambris the gas is absorbed by tampons moistened with water and impregnated with methyl-orange as an indicator, the tampons being of a light yellow colour. The gas then passes over a tampon impregnated with oxygenated water, on which it is retained in the form of sulphuric acid. The pads of cotton wool are placed in an absorbing apparatus of glass through which the air to be analysed is passed. This method enables the gas to be detected in dilutions of 1 in 500,000. Lambris claims that after an exposure for ten minutes the gas can be detected at a dilution of 1 in 2,500,000.

It is necessary sometimes to examine fumes from a chimney to detect the presence of sulphur dioxide, carbon dioxide, etc. The fumes are passed successively into a chamber, cooled on the exterior, where a portion of the steam condenses in tubes of chloride of calcium. The fumes then pass through a dust filter made of a round piece of felt (an examination of the dust is sometimes interesting), into a 25 per cent. aqueous solution of caustic soda, and finally into a water suction pump by which the volume of the gas is measured. The gas in the condensed steam, which always contains sulphuric acid, can be estimated by the iodometric method (Balthazard, 1929).

**HYGIENE**

All necessary precautions must be taken in the manufacture of sulphur dioxide to prevent leakage from kilns and apparatus, to assure intensive condensation of the gas, and to provide an effective ventilating and extracting system in workshops. As regards the protection of the individual, overalls should be worn and breathing apparatus provided with compressed oxygen for the use of workers.

**LEGISLATION**

Women and children are not allowed to work in any sulphur dioxide works in the following countries: Belgium: boys of less than 16 years and girls younger than 21; Greece: boys of less than 16 years and girls younger than 18; Italy: boys under 15 years and girls under 21; The Netherlands: both sexes under 18. In Germany an order of the Chancellor of the Empire dated 22 October 1902, regulates the disinfection and bleaching of brushes by sulphur dioxide; in Great Britain "The Alkali Works Regulation Act" of 1901, as well as the regulations for the chemical industry of 11 July 1922, define the measures to be taken to prevent the escape of poisonous gases (in which sulphur dioxide is included). (See on this subject the article on "Poisonous Gases").

In France, the Netherlands and Russia it is compulsory to notify any damage to health caused by sulphur dioxide.

Legal compensation only exists in British Columbia (eczema caused by the vapour of sulphur); in Finland; in Japan (conjunctivitis caused by irritant gases); in Missouri (United States) (poisonous gases in general), and in Switzerland.

In Great Britain gassing by sulphur dioxide, like other forms of gassing, is classed as an accident and compensated accordingly.

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**Sulphuretted Hydrogen**

(Sulphide of Hydrogen; Hydrosulphuric Acid)

French: Hydrogène sulfurée; Acide sulfhydrique; Acide hydrosulfuratique. — German: Schwefelwasserstoff. — Italian: Idrogeno solforato; Acido solforidrico. — Spanish: Acido hidrotonico.

**PROPERTIES**

Sulphuretted hydrogen (formula H,S) is found in the natural state in certain sulphurous mineral waters, either in a free state or in the state of sulphides or as alkaline sulph-hydrates; and also in emanations from volcanic areas (fumaroles). It is produced each time waters charged with sulphates come into contact with organic materials, and is also liberated during the decomposition of all organic matter which contains sulphur, such as eggs and faecal material.

Sulphuretted hydrogen is a colourless gas, with a very foetid odour of rotten eggs, more offensive in weak than in strong concentrations. Beyond a certain concentration its characteristic odour does not increase in proportion; and at high concentrations, which may very quickly have fatal effects, sulphuretted hydrogen has an odour analogous to that of hydrochloric acid. The odour of this gas is perceptible even at a concentration of 0.001-0.002 per thousand. It is heavier than air, one litre weighing 1.532 grm. at 60° C. and 760 mm. It is also liberated during the decomposition of large quantities of gas in deep cavities such as vats or cellars; and explains why a worker who falls
SULPHURETTED HYDROGEN

into such is immediately plunged into a dangerous atmosphere (Zangger).

At 17 atmospheres sulphuretted hydrogen condenses into a colourless liquid (density 0.91), which boils at -61.8° C. and can be solidified at -83° C.

Inflammable in the air, it burns with a blue flame; when mixed with oxygen it explodes when lighted. Research has shown that the lower limit of inflammability is reached with a strength of between 25.2 and 59 per cent. Other authorities estimate that explosion is produced in the air with a concentration of 0.1 per cent. If the sulphuretted hydrogen comes near a jet of flame.

Sulphuretted hydrogen is slightly soluble in water and very soluble in alcohol, which dissolves 18 times its volume at 0° C. and 72 times at 10° C. The clear aqueous solution, which has a sweetish oily taste, readily becomes cloudy on account of absorption of oxygen from the air. This solidification, set in action by light, makes it necessary to keep the solution in bottles which must be filled full and tightly corked. On boiling all the sulphuretted hydrogen contained in its solutions is set free.

Sulphuretted hydrogen acts as a weak acid; it turns litmus paper a wine red.

Preparation

Sulphuretted hydrogen is obtained in laboratories by the action of dilute hydrochloric or sulphuric acid on sulphide of iron. Chemically it is obtained pure by making sulphide of antimony react on concentrated hydrochloric acid. Industrially it is produced by numerous processes of which the most important are the following: decomposition of sulphide of iron by sulphuric acid in apparatus with or without pressure, of which the latter are preferable, for in case of a leak they do not allow great quantities of sulphuretted hydrogen to escape; treatment of soda lyes (vat waste) by hydrochloric acid; decomposition of sulphide of calcium obtained by the reaction of gypsum and charcoal by means of steam and carbon dioxide; decomposition of sulphur, charcoal and steam at red heat. Sulphuretted hydrogen is liquefied industrially by means of a double-action compressor, the piston of which is always covered with mineral oil, and of a condenser with a worm surrounded by cold water.

Toxic Action

According to Mitchell and Davenport (1924) sulphuretted hydrogen is one of the most poisonous gases. These writers compare it to prussic acid on account of the rapidity with which it acts. Even in a concentration of 0.005 per thousand, such as is found in industry, this gas presents characteristics so toxic as to classify it among the industrial poisons.

This gas is quite poisonous and may even be fatal in concentrations which cannot be detected by smell (Lehmann). Experiments on animals show that a strength of 1.8 mg. to 3.6 mg. per litre of air causes speedy death among cats; that 0.7 to 1.2 mg. is dangerous and even fatal in from half to one hour; that a strength of 0.4 to 0.6 mg. does not cause immediate manifestations, even at the end of 30 to 60 minutes, nor serious ulcer manifestations; and that a dose of 0.1 mg. per litre does not cause important manifestations after an exposure of six hours. No immunity has been observed to be acquired from exposure (Lehmann); on the contrary, an exaggerated sensibility appears, especially after a first attack.

This fact, which has been reported by chemists working with sulphuretted hydrogen, explains the great labour turnover in artificial silk factories of recent erection (Rodenacker).

The irritant action of products steamed in this gas, as dust of paper, films, etc., has also been pointed out.

Sulphuretted hydrogen acts in very weak doses; according to Haggard a strength of 0.01 and 0.15 per cent. causes symptoms of local irritation after some hours of exposure. A condition of this kind is rare outside laboratories. Nevertheless prolonged inhalation can in practice cause chronic poisoning. A strength of 0.02 to 0.03 per cent. causes local irritation at the end of an hour and slight general symptoms at the end of a longer time; a strength of 0.05 to 0.07 per cent. causes local irritation and slight general symptoms at the end of an hour. After several hours (three hours) death occurs from pulmonary oedema.

Hamilton finds that the danger commences with doses of 0.075 per cent. and Lehmann that a dose of 0.05 per cent. of sulphuretted hydrogen causes at the end of thirty minutes coughing, air hunger, palpitation, lassitude, palor, cold sweats, headache, and giddi-
ness. He considers that: a dose of 0.07-0.08 per cent. is dangerous to life in a few minutes; a dose of 0.09 per cent. causes a general poisoning in thirty minutes and death in less than an hour; a dose of 0.15 per cent. is fatal in 15 to 30 minutes, as has already been reported by Oliver; a dose of 0.18 per cent. causes immediate death by paralysis of the respiration.

According to Kranenburg and Kesse, 20 mg. per cubic metre (in artificial silk factories and sugar refineries) has been known to cause conjunctivitis and slight keratitis.

The alkaline sulphides of potassium, sodium, and calcium, in addition to their irritant action, can give off sulphuretted hydrogen, and on this account are dangerous.

Susceptibility to the poison varies very much according to the individual, but it has been constantly remarked that it is increased by previous attacks. In the same way as with a simple, acquired immunity in man has never been observed. This poison has not a cumulative action; further it is not completely absorbed, for, according to Lehmann, the higher the percentage of sulphuretted hydrogen in the air, and the greater the duration of its action, the less completely is it absorbed.

Absorption takes place only by the respiratory passages. Sulphuretted hydrogen in the system exercises a double action: (1) a local irritation of the tissues and exposed mucous membranes of the throat, mouth and eyes, and more particularly of the respiratory mucous membrane; but this local action is often lost sight of when general poisoning supervenes; (2) a general toxic action with a characteristic picture caused by paralysis of the central nervous system (Bohl). If sulphuretted hydrogen is in low concentration, it may exercise a stimulating action; in higher concentrations, it causes a depressing effect both physically and mentally.

Its action on the respiratory apparatus, however, is immediate and proportionate to its concentration. According to Haggard, a dose of 0.1 per cent. has a negligible influence on the respiration. Above this limit, hyperpnoea occurs in a very few minutes; it causes death by cardiac failure, through action on the ends of the vagus nerve. Above 0.3 per cent. death occurs from respiratory failure.

According to Rodenacker, this gas exerts not only a local irritant action, but also a general action on the system. Sulphuretted hydrogen is not a poison of the nervous system even if it causes cramp, which is only the result of an internal asphyxia of the tissues. The poisoned animal has air-hunger even in an atmosphere of oxygen; the fact is this gas is a poison of catalysts, for it transforms iron (which acts as a catalyst) into a ferrous-sulphide compound which is inefficient as a catalyst. Consequently it arrests cell respiration and is the cause of apoplectic deaths. It has then a toxic action analogous to that of prussic acid, which is a poison to catalysts and in a weak concentration irritates the conjunctiva. That is why ocular lesions are not symptoms of a simple local irritation, but of a local arrest of oxidation. This also explains why the intravenous injection of colloidal iron is in this case followed by good results.

Blood. — It is a blood poison which modifies the haematic pigment without causing toxic disturbances (Loewy). The acute cases belong without doubt to the series of anoxaemias studied particularly by Haldane.

All authorities are not agreed as to whether it reduces haemoglobin and transforms the iron contained in the molecule into sulphide of iron (Liebig, Heim), for if that took place, it could only be in very slow forms, ending fatally in a state of coma; whereas death generally occurs too quickly for these reactions to take place.

There is also disagreement as to the possibility of the poison combining with the alkalies of the blood to form alkaline sulphides, notably of sodium. According to Haggard, sulphuretted hydrogen is carried in the blood in the form of a combination which is easily dissociated, for it has been proved experimentally in vivo that sulphide of sodium injected intravenously or intra-muscularly on coming in contact with the blood is hydrolysed and causes a liberation of sulphuretted hydrogen which is eliminated in its turn by the respiratory passages.

According to Hoppe Seyler, sulphuretted hydrogen will combine with oxyhaemoglobin, but not with reduced haemoglobin and will give sulphometahaemoglobin. On the other hand, Harnack considers that it acts only with sulphohaemoglobin, for sulphuretted hydrogen combines with reduced haemoglobin, but not with oxyhaemoglobin. Some authors do not admit these combinations with the formation of abnormal products. According to Haggard, sulphohaemoglobin or sulphometahaemoglobin are never formed in vivo, but can be formed in vitro when...
the blood is totally reduced, and in the presence of toxic doses of a concentrated mixture of sulphuric acid or of the inhaled gas, of which will cause immediate death. On the other hand, German experts admit that the sulphohaemoglobin can be detected, although rarely, during life, and even with a dose of 0.00578 per cent, of sulphuretted hydrogen in the blood (Mayer), when certain particular conditions are realised.

According to Haggard, sulphuretted hydrogen on contact with the blood is oxidised into sulphuric acid or into associated acids which are neutralised by salts of sodium. These products of oxidation are not poisonous. This series of oxidations terminates the physiological action of the gas absorbed, and it is free and unoxidised gas which causes the characteristic toxic symptoms. The blood undergoes a proportional reduction which is, however, insignificant, even when an immediately fatal quantity is absorbed; this reduction does not contribute to increase the poisonous action of the gas.

** Sources of Poisoning **

1. During its preparation. — Escapes of this poisonous gas may occur from the producing apparatus, from derangement of the apparatus, from joints, tubing, taps accidentally turned on, or interference with the ventilation in places where sulphuretted hydrogen is produced. In addition, the sulphate of iron and commercial acids used for the production of sulphuretted hydrogen almost always contain impurities such as arsenic and phosphorus, so that the gas is mixed with traces, more or less important, of arseniuretted and phosphoretted hydrogen.

2. During its use. — The gas may be liberated in laboratories during qualitative and quantitative analyses, in which it is used on account of its well-known acid qualities; it precipitates a great number of metals as sulphides. Too often this gas is made use of without the necessary precautions being taken. Cases of chronic poisoning have been caused even among persons living above laboratories (Zangger).

In Industry there is danger during certain operations: purification of arsenic and metallic acids, especially sulphuric and hydrochloric acid; purification of arsenic; manufacture of cinnabar, antimony, and metallic gold; separation of copper in the nickel and cobalt industry. Sulphuretted hydrogen extracted from soda residues and burnt in the presence of an excess of air gives sulphur anhydride, which is used for the manufacture of pure sulphuric acid. If it is passed with a suitably limited quantity of air over a layer of heated anhydrous oxide of iron, it gives off water and sulphur is generated.

Danger also arises in agriculture where the gas is used for disinfection against the cochylis of vines and against locusts.

3. It is liberated as a by-product in the course of certain operations, either alone or with other gases. In practice this condition is the most frequent, and in these mixed poisonings sulphuretted hydrogen constitutes the most toxic agent: gases from putrefaction; from the manufacture of cyanogen; waste waters from tanneries with carbonic anhydride; gas from blast furnaces with carbon monoxide (Zangger).

(a) In the chemical industry, the gas is generated in the following processes: when acids react with metallic sulphides, more particularly when weak acids are concerned, during the treatment of combinations of potassium and sulphur and of such sulphurous metals as pyrites; during the manufacture of chloride of antimony and barium, by the transformation of barium sulphide into carbonate of baryta, and by the manufacture of chloride of barium from sulphide of barium; during reaction of acids with sulphide of barium, and during manufacture of cyanogen.

It is further generated during the release of sulphurous acid from metals (arsenic), distillation of sulphurous waters, elimination of arsenic from acids (see articles "Hydrochloric Acid" and "Sulphuric Acid"), and during operations producing the reduction of sulphates of organic materials.

It accompanies the manufacture of compounds of sulphur and phosphorus, the manufacture of certain special matches, the manufacture of artificial manures from materials rich in phosphate of lime, when, after crushing, the dissolving of insoluble phosphates by sulphuric acid may cause the liberation of sulphuretted hydrogen and other gases and the manufacture of calcium sulphide.

It may be given off during the use of mastics formed of a mixture of sulphur, sal ammoniac, powdered iron and hot water, during distillation of ammonia, from waste water from wolframic acid, during manufacture of thorium, of incandescent mantles,
during extraction of cellulose, manufacture of nitrocellulose, reaction of cellulose sulphite with acids, during manufacture of artificial silk in the spinning department, and in the manufacture of bisulphite of carbon; also in the use of powdered liver of sulphur, thiosulphate of potash, for making sulphurous baths.

It also is present in the manufacture of ultramarine blue, of methylene blue, of methylene violet, and of Prussian blue, by decomposition of ferro-cyanide of potassium and sulphate of iron, of aniline and its colours.

In the dyeing industry the gas is liberated when sulphur or sulphide of sodium are used as reducing agents in the manufacture of sulphides for dyeing, especially during the reduction of sulphide of antimony by acids; in the manufacture of Leblanc soda, during the efflorescence of the soda residue, sulphuretted hydrogen is produced in great quantities, and is burnt into sulphur anhydride. It also occurs during precipitation of soda residues containing sulphide of calcium.

It occurs in soap works, due to the use of raw soda charged with calcium; in gas works from distillation of sulphurous coal, and the treatment of ammoniacal liquor; in distillation of tar and thick lubricating oils from coke ovens; according to Weyl, they contain 10.7 litres of sulphuretted hydrogen per kg. of materials; in preparing water gas. It is also given off from motors using poor gas.

From acetylene in the raw, unwashed and unburnt state, sulphur from coke becomes oxidised into sulphuretted hydrogen in the process of carburation and immediately decomposed into sulphur anhydride. It is not given off during the use of the oxyacetylene blowpipe.

It is given off in refining raw petroleum. Mexican petroleum contains it up to 0.63-0.83 per cent. It comes off from the tanks and pipes on oil tank ships, etc. The risk diminishes as the end of the distillation is reached.

- It is present in the rubber and vulcanite industry; in the manufacture of substitutes (boiling vegetable oils, sulphur and resins with chloride of sulphur); in tanneries in the preservation of undressed skins, and in soaking dry foreign skins in water. The waste waters of tanneries contain a good deal of sulphuretted hydrogen, according to Oliver, up to 12 per cent. in volume. It is given off during the reduction of chronic acid during the manufacture of leather and during the use for tanning of residues of lime containing sulphide of calcium from gas works, and in emptying cess pits.

It also occurs in factories of artificial silk and accumulators during the cleaning of the plant.

(b) In the metal industry: The gas occurs in the manufacture and use of metallic sulphides; in making sulphide of zinc, for example; during cleaning of blast furnaces and certain boilers containing organic materials; during pulverisation, by the wet process, of waste dross utilised for artificial manures, and for the manufacture of cement and artificial stone, during bronzing of metals by sulphide of arsenic.

(c) In mines: The gas may occur in old mines in consequence of the transformation of pyrites under the action of water and heat. Mine gas and subterranean infiltrations always contain a little sulphuretted hydrogen. In blasting in mines the combustion of powder causes the formation of sulphuretted hydrogen with other gases.

This gas is also very common in the air of the Italian lignite mines (Biondi).

(4) Treatment of organic materials: decomposing organic material.—It is found in waste waters from breweries; and in sugar factories, in water from washing sugar beet; from refineries; and from regeneration of animal charcoal; in glue and mastic works; extraction of fats; in obtaining fats from bones by stewing; in the preparation of guts; knocking, etc.; in the manufacture of soap; during decomposition of large quantities of fats; melting of tallow; in organic fats; during steeping of flax and hemp; cleaning spa baths and pipes conveying hot sulphurous water, cess pits, sewers, and accompanying every kind of putrefaction of albuminoid organic matter.

When these waters are used in such a way as to dispel the sulphuretted hydrogen which is dissolved, this gas may cause trouble (the Netherlands medical inspection department has reported this fact several times).

Statistics

In Austria during the period 1914-1918, 6 cases were reported of which 5 were fatal, and in 1922 there were 2 fatal cases in a tannery.

In Germany, the Industrial Association of Chemical Industries gives the following figures for the years 1906-1912:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases</th>
<th>Fatal cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1906</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1907</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>1908</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>1909</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>1912</td>
<td>19</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>12</td>
</tr>
</tbody>
</table>
SULPHURETTED HYDROGEN

In the period 1914-1918, 5 cases occurred (all fatal). In 1919 in Prussia there were 15 cases, in Saxony 1 fatal case, in the Duchy of Baden 3 cases, of which one was fatal, in Hesse 1 case.

In 1920, 2 fatal cases occurred and in 1921 several cases according to a report by Teleky and Brezina, in which no figures are given. In one chemical works out of 256 workers, 163 were affected with ocular troubles due to sulphuretted hydrogen. In one factory the sickness rate fell from 121 per cent. during the first quarter to 19.8 per cent. during the last quarter after the adoption of prophylactic measures.

In 1922, 2 cases occurred in the process of "bronzing" metals black.

In Great Britain the cases reported to the Chief Inspector of Factories are set out as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases</th>
<th>Fatal cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1921</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>1922</td>
<td>12</td>
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</tr>
<tr>
<td>1923</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>1924</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>1925-1929</td>
<td>35</td>
<td>3</td>
</tr>
<tr>
<td>1929-1931</td>
<td>15</td>
<td>3</td>
</tr>
</tbody>
</table>

In the Netherlands in 1920 there was 1 fatal case in the artificial silk industry; in 1921, 1 fatal case in a gas works and several non-fatal. In the sugar refineries there were notified, in 1922, 96 cases of conjunctivitis and 25 cases in an artificial silk factory.

In Switzerland from 1914 to 1918, 3 cases occurred; in 1920, 4 cases; and in 1921 and 1922, 8 cases; in 1923-1924, 2 cases; in 1925, 3 cases; and in 1926, 1 case. Tauss mentions 3 cases of poisoning, of which 2 were fatal, in obtaining fats from bones. Cases occurred among cess-pit scavengers, i.e. the sudden collapse of these workers. These cases are frequent, but are quoted without any mention of numbers.

In the United States in the petrol refineries the gas caused over a period of years, of which no dates are given, 58 cases of asphyxia, 99 cases of conjunctivitis and bronchitis, 158 cases occurred at the receiving of raw petrol. Hamilton described 8 cases, of which 1 was fatal, in the paint industry.

**Symptoms**

Poisoning by sulphuretted hydrogen can appear in an acute, sub-acute, or chronic form. It generally arises directly from the inhalation of the poison; but it is certain that after a clear interval, serious symptoms may yet occur.

In the fulminating form, which resembles apoplectic seizure, after a few seconds of exposure to an atmosphere containing a sufficient quantity of the poisonous gas, there occur: panting respiration, pallor, cramps, paralysis of the pupil, and, immediately after, loss of consciousness, with loss of speech, or with no other warning than a cry. Death occurs with extreme rigidity from respiratory and cardiac paralysis. There is rarely a preliminary state of anxiety (that is, in the kind of seizure which generally occurs in the sudden collapse of cess-pit scavengers). Sniffing, if sufficiently deep, of liquids containing or giving off sulphuretted hydrogen may be sufficient to cause these phenomena.

Artificial respiration carried out early and kept up till oxidation of the sulphuretted hydrogen in the blood has been effected re-establishes normal respiration without serious after-effects (Haggard), but respiration does not re-establish itself spontaneously on account of respiratory paralysis. Further, deficiency of oxygen slows the process of oxidation of the poison and reduces the respiratory mechanism to a sub-normal state.

With a concentration of sufficient strength, from 0.1 to 0.2 per cent., early hyperpnoea due to the poison is followed by a period of apnoea. In this phase sulphuretted hydrogen is no longer inhaled and what is in the blood, is oxidised. If respiration should start up again, the patient, finding himself in an atmosphere contaminated by the gas, is exposed to fresh poisoning and has less chance of recovery. If respiration is not re-established, death from asphyxia follows.

Sub-acute poisoning is characterised by symptoms due to the irritant action of sulphuretted hydrogen which attacks all exposed tissues and mucous membranes. In the respiratory passages is experienced a sensation of burning and of weight on the chest, irritation, congestion and cough. The alveolar cells are affected by degeneration and destruction and contain transudation and cellular elements. Pulmonary oedema may develop from extremely small doses, and may sometimes also come on gradually, from 3 to 8 days, after the absorption of fairly large quantities of sulphuretted hydrogen, and cause death. Moreover, it is recognised that individuals who appear to have left an atmosphere containing this gas in good health may later show toxic symptoms (Haggard).

Symptoms of pulmonary oedema do not usually appear in the ordinary clinical picture of poisoning, either because they are hidden by the general picture, or on account of the short duration of exposure to the poison.

As regards the eyes, the following symptoms are noted: flashes of light, contraction of the pupil, watering, sharp pains, photophobia, difficulty in keeping the eyelids open, inflammation and ulceration of the cornea, hypersen-
sibility of the conjunctiva to light after an exposure to an atmosphere containing 0.14 to 0.2 mg. for six hours (Lehmann).

The following symptoms have also been reported: Activity of the salivary and sudoriparous glands with abundant salivation and profuse cold sweats, which arise from concentrations of sulphuretted hydrogen, which are, nevertheless, insufficient to cause acute poisoning. Rhinitis and pharyngitis also occur.

As regards the alimentary canal, various troubles arise including nausea, vomiting foetid eructations, larial herpes, foetid breath with the odour of sulphur, intestinal catarrh, diarrhoea, pains in the form of colic.

Sometimes kidney lesions with albuminuria are observed and rarely, glycosuria and urethral infection.

Cardiac troubles, characterised by a marked bradycardia, irritability and especially palpitation on exertion are caused by the inhalation of concentrations insufficient to affect the respiratory system.

Those poisoned complain of giddiness, fainting, lassitude, somnolence, a sensation of falling, heaviness in the head, pains in the neck, persistent headache, anxiety and a feeling of constant malaise.

Among the nervous troubles have been noted: loss of memory in some cases, general agitation, running away with failure to recognise surroundings, attacks of frenzy, stupor, muscular jerks, especially of the lower limbs, tetanic cramps, psychic troubles sometimes going as far as delirium, etc. Natanson and Everovska have reported neuroretinitis due to occupational poisoning by sulphuretted hydrogen.

Prolonged absorption of sulphuretted hydrogen in small but continuous doses, which may sometimes be scarcely perceived by the sense of smell, causes chronic troubles, more particularly with sensitive persons. Furbringer draws attention to the susceptibility of heart and lung cases. Further, susceptibility to the poison increases. In this form, as in the immediate sequelae of acute poisoning, there may be noted, even after ceasing work, irritation of the eyes and respiratory passages, cardiac troubles, digestive troubles, diarrhoea without cause, etc.; anaemia and unhealthy appearance, feverishness, shiverings, cold sweats, skin eruptions and furunculosis, and also depression of the nervous system.

Erben has described marked psychic degenerative troubles, and Kowjenikow a systematic degeneration of the spinal cord, with encephalitis and myelitis. Nathanson and Roserowa have reported neuroretinitis and chronic meningitis. They consider that in chronic poisoning sulphuretted hydrogen particularly attacks the nervous system having a selective action on a given part of that system.

Analysis of symptoms, as well as the facts supplied by literature, suggest the possibility of a lesion of the meninges in chronic cases, all the more so that even weak doses can be poisonous if the action is prolonged.

In acute cases recovery or death often occur before there is time to intervene. If recovery takes place, then the after-effects do not last more than a few hours.

In the sub-acute cases, signs of irritation of the mucous membrane may last for some time. It must not be lost sight of that death may occur 12 to 48 hours after from pneumonia, oedema, etc.

In chronic poisoning serious sequelae may arise in the nervous system, but some writers only admit this with reservations (Biondi, for example). In the other forms sequelae are relatively rare. Nevertheless, diabetes (Cahn), blindness (Hamilton), and some cases of insanity and mental depression have been reported.

Among scavengers, sequelae are very common in the nervous system, but they arise especially from the absorption of putrid materials, when those poisoned have fallen into materials in a state of liquefaction.

**Prognosis**

The prognosis in acute, as in chronic, cases is comparatively bad. Sometimes troubles of long duration are found in the nervous system and in the heart. When such poisoning is under consideration, the possibility of a neuritis must especially be left out of account.

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1 Rodenacker, of Wolfen, has studied (1925) the question of ocular troubles among women working in viscose factories (see article "Artificial Silk"). It is recognised that cases of conjunctivitis among these workwomen are especially frequent when a recently started factory is concerned. Acute and painful irritation of the conjunctiva has been attributed by later to sulphuretted hydrogen and organic compounds of sulphur; by Stiebel to sulphurous anhydride; by Bakker to sulphuretted hydrogen and to organic compounds of arsenic and chlorine; by Knapp, Kranenburg and Lehmann to sulphuretted hydrogen alone. The odour of viscose should be due to sulphuretted hydrogen which is formed during decomposition of triothiocarbonate of sodium in the reaction: \( \text{Na}_2 \text{CS}_2 \rightarrow 2 \text{CS}_2 \text{H}_2 \text{O} \). The formation of sulphuretted hydrogen again occurs in the tanks where spinning materials are steeped, following on the decomposition of triothiocarbonate acid.
SULPHURETTED HYDROGEN

and effort must be made to seek out the etiology (Zangger).

DIAGNOSIS

This presents some difficulties. In a case of probable poisoning by sulphuretted hydrogen, it is absolutely necessary to know the previous history and to study the environment of work. As a matter of fact, autopsy, almost without exception, gives no indication, even in confirmed cases of poisoning; hence, as fatal poisonings come under this definition used to-day for occupational accidents, use must be made of all sources of information.

Death generally supervenes too quickly for changes in the blood to occur.

Detection of sulphohaemoglobin or of sulphonmethaemoglobin in the blood would obviously be characteristic evidence; but their existence after an attack is disputed by some writers. It seems that, if the sulphocompounds may be formed, they are not formed during life, but rather after death, and arise from post-mortem changes. Lehmann moreover suggests that pulmonary oedema is the usual thing (see article "Blood").

Clearly other symptoms caused by the poison gas ought to be diagnosed; but often their etiology is not recognised, or an erroneous etiology is introduced.

DETECTION

Sulphuretted hydrogen is recognised by its smell of rotten eggs, but that is not a sufficient indication of its strength in the air.

Qualitative Detection

(a) Paper that has been treated with acetate of lead is used. Blackening occurs in consequence of the formation of sulphide of lead. But long contact with sulphuretted hydrogen makes the paper become white again due to the transformation of sulphide of lead into the white sulphate, especially when there are only traces of gas to detect.

(b) Sheet copper may be used. Blackening occurs if there is a large quantity of sulphuretted hydrogen; a velvety surface appears on the sheet when it is put in an atmosphere containing sulphuretted hydrogen.

(c) A thin sheet of silver that has been moistened may be used. Blackening takes place due to the formation of sulphide of silver.

(d) The suspected air may be shaken up in water to which has been added 2 per cent. of hydrochloric acid, a piece of sulphate of paramidodimethylaniline, and then a drop of perchloride of iron. If sulphuretted hydrogen is present, the aqueous solution turns a beautiful blue colour due to methylene (Caro and Fischer).

(e) An alkaline solution of nitroprussiate of soda in the presence of sulphuretted hydrogen takes on a violet colour (Reichard) which is perceptible when only 0.018 mg. of this substance is dissolved in an acid or alkaline sulphide. The sensitiveness of the reaction depends on the concentration of the solutions rather than on their absolute quantity.

It is best only to resort to colorimetric procedure when a test cannot be otherwise made, for it necessitates certain tentative processes, and is liable to certain causes of error (Heim).

For example, the methylene blue process is somewhat delicate to manage. The nitroprussiate process is, at its best, less sensitive than the metal salt processes. The reaction of colour turning in the presence of sulphuretted hydrogen is less sensitive, for example, than that of the black colouration of acetate of lead. This process then does not allow the colorimetric estimation of the gas on account of the difficulty of gauging the colour.

Quantitative Detection

The quantity of sulphuretted hydrogen in factory atmospheres, although rarely very great, necessitates the employment of quantitative methods. The estimation can be made with Tutweiler's iodide apparatus, or, according to the process of Lehmann, by making the air pass into a decinormal solution of iodine and determining the diminution of iodine with a decinormal solution of thiosulphate. One cubic centimetre of diminution of the standard corresponds to 1.7 mg. sulphuretted hydrogen.

If the percentage present is sufficiently strong, it can be dealt with on a mercury bath. The gas is absorbed by the help of a ball formed of two parts of weight of ordinary precipitated sulphate of lead and three parts of calcined gypsum mixed and compressed at the end of a platinum wire. This ball, having been dried at 110 °C, and then soaked in phosphoric acid, is ready for use (Ludwig).

Heim uses a method of estimation based on the action exercised by sulphuretted hydrogen on a solution of iodine of a definite concentration and determines the excess of iodine by hypoiodite of soda. This seems to be the best method.

A fixed volume (ten litres for example) of the suspected air is made to pass through a Liebig's absorbing tube containing ten cubic centimetres of centinormal iodine (12.7 grm. of iodine dissolved in a solution of distilled water containing 4 to 5 grm. of potassium iodide diluted to a litre after the dissolving). The iodine is taken up and forms hydriodic acid and sulphur. Absorption of the slightest traces of sulphuretted hydrogen is complete, provided that the passage of the air
through the absorbing tube is sufficiently slow for the reaction to have plenty of
time to take place (Fresenius). The speed
should not exceed two bubbles a minute.
The content of the absorbing tube is
emptied into a beaker; then the tube is
rinsed with distilled water which is added
to the original liquid. This liquor is
brown in consequence of the presence of
an excess of iodine. Some drops of a 1
per cent. solution of starch paste are added, when a deep blue appears, due to iodide of starch.
The existing iodine is estimated with a
solution of standardised hyposulphite of soda which is added until the starch-
iodine colour is affected up to the final
turning of the liquor; ten cubic centi-
methres of the solution should decolorise
exactly ten cubic centimetres of centi-
nae of iodine or in the vicinity. The sili-
ness of the estimation, corresponding to
0.017 mg. by weight of sulphuretted hydro-
gen is quite sufficient. The method of
carrying out the process is facilitated by
the use of a "sulph-hydrometer", which
contains the apparatus and the necessary
reagents for taking the sample and the
estimations.

PROPHYLAXIS

First aid. — In the case of subacute
poisoning, move the patient into the
open air, start artificial respiration by
the Schäfer method, which must be
stopped as soon as normal respiration recom-
menes. Administer a mixture of
oxygen and 5 per cent. carbonic acid,
heart tonic stimulants, ether, campho-
rated oil, etc.

Avoid fouling the air with sulphur-
etted hydrogen. Do not rely on the
smell to detect its presence, and esta-
blish a careful control. Install a
system of artificial ventilation in work-
places. Instruct the workers in the
danger. Organise first-aid equipment.
Mechanical arrangements should en-
sure work being done in closed appara-
tus in safety. It is not sufficient to
remove sulphuretted hydrogen by carry-
ing it off at the actual place of pollu-
tion; the gas must be followed in all
its ramifications so as to ensure that it
does no harm to persons employed in
the factory or in the vicinity. Spec-
tacles, respirators and breathing appa-
rateus may also be used when the
ventilation is not sufficient to eliminate
sulphuretted hydrogen.

In certain cases special precautions
must be taken: thus, for the emptying
of cess-pits it is necessary as a prelimi-
nary measure to put in ferrous sul-
phate, at the rate of five kilos per cubic
metre of materials, or, better, to use
sulphate or chloride of zinc. Workers
should wear safety ropes so that those
poisoned can be rapidly dragged out;

soiled clothing must be immediately
removed. It is still better to carry
out the emptying by mechanical means.

LEGISLATION

The regulations provided for poisonous
gases (see article "Gases and Fumes"
should be applied to sulphuretted hydro-
gen; as regards first aid, it must be re-
membered that rules have been laid down
by the Trade Association of the Chemical
Industries of Germany (1 January 1912).
The notification of injuries caused by
sulphuretted hydrogen is compulsory in the
State of Missouri (poisonous gases),
in France and in the Netherlands; compen-
sation is provided in Switzerland, as
well as in countries which compensate
poisonings due to poisonous gases (Great
Britain, Finland and Germany). Acute
cases are generally considered as acci-
dents.

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Prof. H. Zangger

( Zurich).
Sulphuric Acid


Properties

Ordinary sulphuric acid is an oily liquid — colourless, inodorous and heavy — of which the specific gravity varies from 1.07 to 1.8 (pure acid), according to the degree of concentration. This also causes the boiling point to vary; the acid at 62 per cent. of sulphuric acid (50° Be) boils at 147° C.; at 78 per cent. (66° Be) at 200° C.; at 95 per cent. (66° Be) commences to boil at about —34° C. in consequence of the dissociation by heat, the acid should always be handled at the ordinary temperature whatever the concentration, but must be freed from dust, especially to get rid of some of the arsenious oxide that may be present in air and water.

Sulphuric acid does not fume in the air, but gives off vapour even at 30° C.; on boiling, these vapours are heavy, white, and have a sharp smell. At about 400° C. it decomposes into sulphuric anhydride and water. It is often yellow in colour or brown from impurities (traces of organic matters, dusts which are carbonised, etc.). Other impurities present may be lead sulphate, arsenic, copper, antimony and nitrous fumes.

Fuming sulphuric acid or oleum (Nordhausen acid, vitriol oil) is a thick liquid, with a specific gravity varying from 1.86 to 1.89, coloured more or less brown (from traces of organic substances), or without colour (the pure acid used in the manufacture of explosives), formed of a mixture of ordinary sulphuric acid and sulphuric anhydride of varying proportions (as much as 80 per cent. of the anhydride: SO₃). At certain concentrations it crystallises in part into a mass melting at 35°. It gives off white dense fumes spontaneously, and on heating forms sulphuric anhydride.

With water, which they attack greedily, sulphuric acids form combinations (hydrates) with development of much heat. To avoid accidents arising from the liberation of heat, the acid should always be poured into the water — never the contrary.

Sulphuric acid, under certain conditions, attacks metals, giving rise to acid or neutral sulphates. The concentrated acid (66° Be) does not attack iron or steel, this enabling it to be kept and moved in iron tanks, which, on the contrary, are attacked by dilute acid. Lead is not attacked at the ordinary temperature whatever the concentration, but is attacked by evolution of sulphur anhydride by hot acid at a strength of 60° Be. Copper, mercury, silver, antimony, arsenic, sodium, etc., when heated with sulphuric acid also give off sulphurous anhydride. Zinc, iron, aluminium and magnesium yield sulphates and hydrogen. Platinum and gold are not attacked.

Manufacture

Sulphuric acid is made principally from sulphurous anhydride, as the starting point, by the lead chamber process or by the contact process.

For the preparation of sulphur dioxide, see that article. It should be remembered that in its preparation from the roasting of pyrites, the air serving for the purpose should be admitted into the furnace in such proportion as to produce sulphurous acid and should contain the necessary excess of oxygen for the oxidation processes. The transformation of the sulphurous anhydride into sulphuric acid is the only way in which this gas can be utilised in the roasting of blende, and the manufacture of sulphuric acid is always, therefore, an annex to a zinc works (see that article). The gases, on leaving the chamber where they are produced, must be freed from dust, especially to get rid of some of the arsenious oxide formed if the roasted iron pyrites is arsenical. This is carried out in dust chambers or by cooling, or by special apparatus of various kinds (filters, centrifuges, electrical, etc.). The gases from roasting, further, contain a considerable quantity of sulphuric anhydride from the direct union of sulphur dioxide and oxygen through the intervention of the residual oxide of iron from the furnaces which acts as a catalyst (see below, the Contact Process).

Lead Chamber Process

This consists in converting the sulphur dioxide into sulphuric acid in large lead chambers by the action of the oxygen of the air and water in the presence of nitrous fumes. The exact chemical reaction is not yet accurately known. Many theories have been put forward, of which the most generally accepted is that of Lunge, which may be summarised as follows:

Sulphur dioxide, when nitric acid is added, yields: (1) sulphate of nitrosyl, which on contact with steam is decomposed into (2) sulphuric acid and oxides of nitrogen. The latter reforms (3) nitrosyl sulphuric acid under the action of the oxygen of the air and sulphur dioxide gas. These reactions are continuous and follow a closed cycle (2) to (3) and vice versa. The only additions necessary are water, air, and sulphur dioxide.
There are secondary reactions in which different oxides of nitrogen are also formed. The nitrous fumes introduced into the Glover tower (see below) before passage through the lead chambers must not be lost and are recovered in a special apparatus down which sulphuric acid trickles (Gay Lussac tower). The nitrosulphuric acid thus obtained is carried again to the Glover tower, where the oxides of nitrogen are again evolved. Nitric acid is only added to compensate for loss due to leakages in the plant.

**Glover tower.** — On leaving the dust depositing installation, the gases are led at a temperature of 390°C into the Glover tower at a point low down, while in the upper part the nitrosulphuric acid coming from the Gay Lussac tower is distributed. The Glover tower is made of thick lead sheets, lined with acid-proof bricks. It is filled with coarse flint or fire-clay cylinders. The acid carried to the top of the tower is denitriified; the nitrous fumes escaping from the lead chambers and arrested in the Gay Lussac tower are recovered whilst at the same time concentration is effected by heat and absorption of the sulphur dioxide. The acid collected at the bottom of the tower is at 60° to 62° Bé.

**Lead chambers.** — On leaving the Glover tower the gases are driven by fans into the lead chambers, which vary in number (from one to twelve). Generally they form a system of three, having a total capacity of 4,000 to 8,000 cubic metres. Each chamber consists of a huge leaden bell, supported by a wooden framework and suspended over a tank similarly constructed of lead. The acid thus lustes the chamber from the outer air. Thermometers are hung on the walls to record the temperature; lanterns allow the colour of the gas and the progress of the process to be watched. The largest portion of the sulphur dioxide is changed in this chamber into sulphuric acid under the action of air and atomised water in the presence of nitrous fumes. The nitrated products are introduced in the form of nitric acid, which is made to flow slowly over glass or earthenware plates, or pulverised into a fine rain. The water is introduced into the first chamber in an atomised state.

In recent installations, between each chamber towers of the Glover type have been introduced, which has enabled the size of the chambers to be lessened.

The acid collected from the lead chambers is diluted to 50°-53° Bé (about 60 per cent. of pure acid) and used directly for certain kinds of manufacture (e.g. 1)

1. The oxides of nitrogen are introduced into the chamber system either by the decomposition of saltpetre or by injecting nitric acid into the first chamber, or by catalytic oxidation of ammonia, or by injecting nitric acid into the Glover tower.

2. Gay Lussac and Glover towers are nowadays built entirely of masonry.

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1. To introduce the nitrous fumes other methods may be chosen: addition of saltpetre to the minerals; addition to the gas of oxides of nitrogen prepared in special furnaces; addition of nitrate of lime or nitric acid in the Glover towers, etc.

2. The chambers can be replaced by leaden towers resembling a reversed cone (Gaillard) or by cone-shaped chambers (Mills-Packard system, U.S.A.), etc. The methods of nitration proposed quite recently dispense altogether with lead chambers. Several processes have been patented recently for types of intermediary towers for cooling and mixing the gas. Placed between the chambers, they multiply the surfaces of contact.
superphosphates) or sent for further concentration.

Gay Lussac tower. — This is constructed in a manner similar to that of the Glover tower, but it is taller. The nitric acid in the lead chambers on reaching it comes into contact with the acid at 62° Bé from the Glover tower with its flow directed from above downwards. Nitroso-sulphuric acid is formed, and the oxides of nitrogen are thus recovered. After denitrification the gases escape by a chimney. The nitric-sulphuric acid collected at the bottom of the Gay Lussac tower is sent to the top of the Glover, where, as has been seen, the oxides of nitrogen enter into the manufacture.

Several Gay Lussac towers are often necessary to make sure of good recovery and to prevent the escape of nitrous fumes into the atmosphere. All the apparatus is linked up by lead pipes. Circulation of the gas is maintained by a chimney placed at the end of the system and by a leaden fan (or one of acid resisting fire-clay) placed before the first chamber or between the Gay Lussac towers.

Transference of the acid into the towers is effected by means of compressed air. Different systems allow the acid to be distributed uniformly at the top of the towers (hydraulic tourniquets, Delplace syphon, etc.)

Concentration and purification. — The first is effected in apparatus of various kinds (often simple tanks) made of lead, platinum containing iridium or gilded, glass, porcelain, silicious material, ferro silicon (apparatus of Benker, Kessler, Girard, Gaillaret, etc.). The acid is finally subjected to purification. The arsenic is eliminated by spreading out in narrow vertical iron tubes and on perforated plates. The reaction has to take place at 550° C. — a temperature which is maintained by suitable arrangements for heating and cooling. As they leave the contact chamber, the gases are cooled in a coil and then made to bubble through nitric acid in sheet steel absorbing cylinders, lined on the inside sometimes with acid resisting material. A solution of 20 per cent. or of about 69-70 per cent. of anhydride in sulphuric acid is obtained.

Oleum is obtained most economically by dissolving the sulphuric anhydride from the contact process in the sulphuric acid obtained from the lead chamber process.

Sulphuric acid can again be got from gypsum. A mixture of strictly defined proportions of gypsum, clay and coal finely pulverised and heated catalysts is transformed into sulphuric acid. The principal product is the cement and the acid is merely a by-product.

Sulphuric acid is marketed in carboys or bottles containing 60 litres, packed in iron crates stuffed with straw. Transport of large quantities is done in tank wagons or in wagons made up of eight large vitrified earthenware cisterns. Acid with a concentration above 60° Bé can be carried in cylinders of iron.

Toxic action

Sulphuric acid fumes exert a slightly irritating action like those of other mineral acids (see articles "Nitric Acid" and "Sulphur Dioxide"). The presence of 0.5 to 2 mg. of the vapour per cubic metre of air is hardly detectable by man; from 3-4 mg. per cubic metre becomes noticeable, and from 6 to 8 mg. strongly so.

The action of the acid is essentially due to its avidity for water and to the changes so induced in albuminoid substances. When the acid is diluted the impurities it may contain play their part (see following paragraphs).
Dangers of Poisoning

In the Course of Manufacture

The dangers in the lead chamber process are as follows:

1. Acid fumes. — The acid fumes (from sulphur dioxide, sulphuric acid, and nitrous fumes (see these articles)) act on the mucous membranes and respiratory tract. The fumes may escape in quantity, in which case the danger arises not only from continuous and constant inhalation of small quantities, or from staying in the chambers containing slight concentration, but also from extensive absorption of large quantities, especially when the process is not working properly. The trouble in question used frequently to occur with the old roasting furnaces. The danger from acid fumes is present on entering the lead chambers, when they have to be cleaned, or when taking samples (but here nitrous fumes are the main source of risk); in the course of concentrating the acid (when large quantities of the fumes are evolved); in the course of carrying the acid (fatal cases have been reported as a result of fumes as well as burns from breakage of the receptacles); in cleaning the tank wagons, etc.

2. Arsenic compounds. — Danger arises from the gases given off in roasting which may contain arsenic acid if the pyrites is arsenical. The lead burners and fitters of the lead chambers run a risk of arsenic poisoning if they use a hydrogen blowpipe made from zinc and sulphuric acid. When these two products contain arsenic, arsineuretted hydrogen gas is formed, which may poison the workman directly by escape from the pipes, or from combustion in the flame when it is converted into the very poisonous arsenic acid. Arsineuretted hydrogen gas may also be given off in removing by means of dilute sulphuric acid the mud containing traces of arsenic at the bottom of the iron tank wagons.

3. Lead poisoning. — Chronic poisoning has been observed among the lead burners and fitters of the lead chambers, as well as among those engaged in cleaning them. The risk of poisoning among them is all the more serious as they are skilled workmen, which makes a change of employment difficult.

4. Poisoning by sulphotretted hydrogen. — Poisoning by sulphotretted hydrogen arising in the purification of sulphuric acid has also been noted.

In the Course of its Use

The danger arises from the liquid used and the fumes given off. Among the many applications of sulphuric acid (almost universally used in the chemical industry) the most important are: dilute chamber acid (50-52° Bé) for making hydrogen gas, carbonic acid gas, hydro sulphuric, hydrocyanic acid gas, different sulphates (aluminium, zinc, copper, barium, iron, etc.), alum, etc.; to obtain weak acids: citric, tartaric; to make peroxide of hydrogen, colours (aniline black); in tanning hides; in carbonising wool; in scouring, etching and engraving metals; in accumulator manufacture (formation); for various galvanic technical purposes; in the making of yeasts, the treatment of molasses, etc. Very dilute acid has been employed in agriculture for the destruction of weeds; acid from the Glover tower (60-62° Bé) is used for making superphosphates, ammonium sulphate, artificial manure, soaps, stearine, oleine, wax, sulphate of soda and Leblanc soda, various metallic sulphates, mineral acids (hydrochloric, nitric, hydrobromic, chromic phosphorus, bromine, iodine, potassium bichromate; for the oxidation of organic compounds by a mixture of sulphuric acid and potassium bichromate; for the purification of fats and oils; in the metallurgy of cobalt, nickel, silver and gold.

The concentrated acid (66° Bé) is used in the preparation of concentrated mineral acids (nitric, boric) and numerous organic products: acetic, tartaric, phenois, sulphuric ether and different ether compounds; sulphonated, organic acids, artificial colours; for the sulphonation of a certain number of organic compounds, for drying gas, for the purification of vegetable, animal and mineral oils as well as paraffins; for nitrating organic matters (mixed with nitric acid) to give important products, generally explosives: nitro-cellulose, nitro-glycerine, gun cotton, nitro-benzene, etc.

The uses of oleum similarly are numerous and important: sulphonation of organic substances, the manufacture of sulphonated organic acids, intermediate substances, colouring matters, alizarine, phosgene, saccharine, purification and refining of mineral oils, etc.

Statistics

These are not numerous, and, further, often include cases set up by hydrochloric acid or other acids. In Switzerland cases of intoxication or ulceration giving
rise to compensation as accidents numbered 2 in 1918; 2 in 1919; 13 in 1920; and 11 in 1921.

Several severe — even fatal — cases have occurred to workmen engaged in cleaning Gay Lussac towers and during the rectification of the distillates from naphtha by sulphuric acid. This is not the place for dealing with the caustic effects, burns, etc., occurring to the workmen manipulating sulphuric acid, which naturally do not appear in international statistics.

According to Leymann (1906), 1,389 workers engaged in German sulphuric acid factories showed for the period 1881-1904 the following sickness rates: for 100 workers 1.0 nervous diseases, 15.1 respiratory diseases, 14.4 digestive diseases, 8.9 infectious diseases, 5.5 burns, 9.5 external lesions, 9.2 diseases of the locomotor system, 3.4 dermitis.

**SYMPTOMS**

The lesions affect mainly the mucous membranes, the teeth, the skin, and the respiratory tract.

The burns by sulphuric acid, according to Gaucher and Gougerot, may be simple, indolent, or exuberant. Some burn more rapidly like a small wound, leaving a slightly pigmented cicatrice. If it is not very extensive the burn has sharply defined edges and is characterised by inflamed areas starting from a bluish centre and spreading into the healthy surrounding skin. Some burns cicatrise slowly with an ulcerated and infiltrated base; the cicatrice is violet brown, pale at the centre and deep in colour at the periphery where the retracted skin is thrown into folds. The scar tissue is supple and infiltrated, the pigmentation often extends to the healthy peripheral parts. If the ulceration is open cicatrisation is slower with violet granulations which are troublesome to treat.

At the time of burning by the liquid there is pain, blanching and later browning of the skin, desquamation, and after some minutes' redness, swelling of the tissues near the part burnt, and production of the condition described above. If the skin lesion is extensive, massive bloodstained coagulation occurs, with duodenal ulceration and rapid death in a state of coma. The urine need not be altered, but it often contains albumen, hyaline epithelial casts, and blood. As a result of the products of disintegration of the albumen circulating in the blood there may be rise of temperature. When a severe lesion heals it does so often with formation of adherent scar tissue necessitating not infrequently plastic operations.

According to Leymann, burns reached a rate of 5.5 per cent. amongst workers in the sulphuric acid industry, whilst the figure is only 1 per cent. for all the workers in the other chemical industries.

Lesions of the respiratory system are set up by acid fumes, either by the direct action of the fumes on the mucous membranes or by absorption of atomised acid present in the atmosphere, as for instance in workshops in which storage batteries are charged. Pain does not set in just at once. According to Leymann, the number of patients suffering from affections of the respiratory system exceeds that for the whole industry, and in the acid factories respiratory disease chiefly attacks the workers engaged on the manufacture of the products properly so called. Sometimes the irritant lesions are sufficiently serious to cause death (for further details, see article "Nitric Acid", "Sulphur Dioxide", "Acids", and "Chemical Trades").

On the ocular mucous membranes the acid fumes or droplets of acid set up conjunctivitis, keratitis with formation of leucoma, scarring, etc. Some cases of blindness are described.

The effect on the teeth is characteristic and points to chronic action of the acid fumes (see article "Mouth and Teeth").

**Diagnosis** presents few difficulties.

**DEMONSTRATION**

Lehmann has suggested aspiration of a known quantity of air through moistened cotton wool, and then titrating by a solution of caustic soda with Congo red as an indicator or precipitation by barium sulphate.

**HYGIENE**

Application of all the measures recognised for the construction and maintenance of premises devoted to chemical operations (flooring, walls, cleanliness, etc.). Factories should not be near dwelling houses unless condensation of the fumes is perfect. Injurious fumes should be absorbed or condensed, localised fumes should be effectively retained in completely closed and airtight apparatus, or kept under a negative pressure by artificial ventilation, if necessary.

The pyrites furnaces should not allow gas to escape and the burnt pyrites should not be withdrawn from the cinders until they have been sufficiently cooled to render them inodorous. Gases if not absorbed ought not to be discharged into the atmosphere except through a very tall stack. In a well-managed works the
content in acid of the final gas should not exceed 0.1 per cent, in volume. In Great Britain, the Alkali, etc., Works Regulation Act of 1906 lays it down that a sulphuric acid works must not allow the escaping gas to exceed 4 grains of sulphuric acid in each cubic foot corresponding to 26 per cent. of sulphur. A sulphuric acid works must not allow the residual content in acid of the final gas to exceed 0.1 per cent, in volume. The Regulation Act of 1906 lays it down that the acid of the final gas should not exceed 0.1 per cent, in volume. In Great Britain, the Alkali, etc., Works Regulation Act of 1906 lays it down that a sulphuric acid works must not allow the escaping gas to exceed 4 grains of sulphuric acid in each cubic foot corresponding to 26 per cent. of sulphur. A sulphuric acid works must not allow the residual content in acid of the final gas to exceed 0.1 per cent, in volume. The Regulation Act of 1906 lays it down that the acid of the final gas should not exceed 0.1 per cent, in volume. In Great Britain, the Alkali, etc., Works Regulation Act of 1906 lays it down that a sulphuric acid works must not allow the escaping gas to exceed 4 grains of sulphuric acid in each cubic foot corresponding to 26 per cent. of sulphur. A sulphuric acid works must not allow the residual content in acid of the final gas to exceed 0.1 per cent, in volume.

The construction, maintenance, and cleaning of the towers and chambers should be carried out according to the recognised rules for safety. The emptying and cleansing of the Gay Lussac towers and of the chambers should be done mechanically and from the outside. If this system cannot be adopted, after careful washing with water and steam (to eliminate the nitro-sulphuric acid) to remove the mud remaining on the floor of the chambers and towers, tests of the air should be made as to the presence of acid gases before allowing the workpeople to enter. If gas is present the washing should be repeated. Exhaust ventilation should be maintained from above downwards so as to draw the fumes away from the men engaged in cleaning operations. Circulation of the acid should be maintained automatically. The gases should be completely purified so as to obtain a product free especially of traces of arsenic. Workrooms should be well ventilated. Gas pipes should be tested periodically and maintained in a good state of repair so as to avoid all escape of poisonous gases. Arrangements should allow of examination for, and verification of, the state and nature of the gases.

All apparatus and pipes should be kept as airtight as possible in factories making use of the contact process. Where repairs have to be made, work should be stopped and a fan installed behind the reservoir for absorption of the sulphur dioxide. The residual gases should be passed over a filter of sand to rid them of acid. Conveyance of the acid and mixtures containing it should be carried out in a closed system by compressed air.

Workmen engaged in cleaning and repairing should have sufficient and suitable breathing apparatus or respirators placed at their disposal. It should be remembered that no substance used for impregnating the mask is capable of neutralising the toxic action of the oxides of nitrogen. The workmen should be instructed as to the danger they are exposed to during the cleaning of the reservoirs.

No solid or liquid product should be allowed to run into water courses or pits without having been previously cooled and neutralised. The danger of lead poisoning to men employed in the lead chambers should be recognised and preventive measures taken.

In the course of manipulation, the filling of receptacles which previously have contained soda or oleum with sulphuric acid, or, inversely, the filling of receptacles which have contained sulphuric acid with soda is dangerous without careful cleaning. Great care also should be taken in cleaning apparatus, receptacles, etc., which have contained sulphuric acid. Transport should be made in receptacles of iron or fireclay carboys, or in special wagons allowing transport, and emptying should be done in such a way as to avoid all chance of splashing or upsetting. Generally speaking, acids or alkalies should be pumped or aspirated into receptacles rather than be poured in, because the pressure always causes some to escape into the air. When it becomes necessary to enter tank wagons to clean them special precautions should be taken, such as preliminary energetic ventilation continued even during the operation of cleaning or washing with a hose pipe or with a dilute solution of soda. Removal of the mud by scouring should be done without the necessity for men having to enter the reservoir. If a carboy breaks, sawdust should never be used for lappping the escaped liquid because it gives rise to formation of large quantities of sulphur dioxide which attack the respiratory tract. (See also article "Acids ".)

Personal preventive measures include wearing of gloves, goggles and clogs; use of breathing apparatus where necessary. Oxygen recovery apparatus should be available.

First aid is the province of the medical man, but effort should be made immediately to neutralise the action of the acid by the use of alkali or starch.

Legislation

Women are forbidden to work in sulphuric acid factories in Argentina. Young persons under sixteen years of age are excluded from such factories in Belgium and Quebec (Canada); under eighteen in France (from workrooms where fumes are given off or where acid is manipulated) and in the Netherlands; male young persons under fifteen are excluded in Italy, Greece and Japan, and under sixteen in Spain. Female young persons under eighteen years are excluded from such factories in Greece and under twenty-one years in Spain, Italy and Japan.

Special requirements have been laid down in Germany by the Federation of Chemical Industries (it. Anz. 1893, No. 283)
having special odour when fresh and, an astringent

The leaves and young buds of certain plants belonging to the Rhus and Coriaria families furnish sumac, which is one of the best substances used in the tanning of skins. The most commonly cultivated kinds of sumac are the Rhus Cordaia Linn. (true sumac of Asia Minor and the Mediterranean countries and especially of Sicily, where it grows in the form of a shrub 3 to 4 metres high in various regions, even the most arid, without much attention); Rhus cotinus Linn. (tintorial sumac), in Europe and in Asia; the Cordaia Myrtifolia Linn. in Central Europe and North Africa; the Rhus glabra Linn., the Rhus Typhina Linn. (American sumac), etc. In Italy the leaves harvested generally from July to September are collected in various depots where they are spread out for drying when unduly moist. They are then sorted, freed by ventilation from debris (earth, pieces of wood, etc.), freed from stalks and small branches, then made into compressed 'balls and covered with cloth sewn together at the edges or tied with string, each ball weighing about 250 kg., 100 kg. of crude sumac give about 80 to 83 kg. of sumac in leaf form as placed on the market, 4 to 6 kg. of earth and 12 to 16 kg. of wood.

Leaves of Sicilian sumac in the dry state have a clear greyish green colour and are covered on both surfaces by fine hairs of a very characteristic form. Powdered sumac is soft to the touch and of a yellowish grey-green with an agreeable odour when fresh and an astringent taste. In the damp state it is liable to fermentation. Sicilian sumac contains 21 to 30 per cent. of tannic and 4 to 52 per cent. of extractive substances which are not tannic, and 6 per cent. of ash. The yellowish colouring material is myrecite.

The preparation of powdered sumac takes place in special workshops where the leaves are ground after being well dried. The product obtained is passed through a series of sifting machines which impart to the powder various degrees of fineness and eliminate impurities. The latter (unsifted parts, ligneous material, peduncles of leaves, small rootlets, etc.) are returned for further grinding and sifting. The various powders are then mixed in order to give the commercial product. The powder after preparation is placed in sacks and stored or exported.

Sumac is utilized for tanning goat and sheep skins in the Morocco leather industry, for dyeing cotton Turkey red and for dyeing a grey colour with salts of iron. It is finally employed as a mordant and as a loading or weighting agent in the manufacture of silk.

Sumac extract is obtained by treating powdered sumac with water. The solution is filtered, bleached and concentrated.

The extract is in the form of a liquid more or less dense according to the concentration, of yellowish or light brown colour with a very astringent taste. It is used in the tanning of light skins and for clarifying in all kinds of tanning in order to soften the surface of the skin. It is likewise used in dyeing.

Sources of Risk

The sources of risk are conditioned principally by the dust from the sumac, which is very abundant in course of grinding.

The atmosphere near the grinding mills is so laden with dust that it is impossible for anyone coming from outside to breathe freely even for a short length of time.

Guardione (1913) reports that workers handling sumac are in the habit of tying over their mouths and noses a handkerchief which is knotted at the back of the neck in a loose fashion in order that it may constitute a sort of bag permitting at once of the entry of the air and serving as a kind of filter. During the first hours of work this handkerchief constitutes an effective protective mask, but little by little the respiratory surface diminishes, since it is rendered damp by the breath and therefore more liable to retain the particles of sumac dust. On this account the workers engaged in grinding should be obliged to remove their masks and be sent into the open air every hour. Workers engaged on emp-
tying the machines and working in a less dusty atmosphere might, on the other hand, retain the protective handkerchief for the full length of the working shift.

This dust appears to exercise a purely mechanical action on the mucous membranes, although certain authorities are of the opinion that sumac also exerts a bactericide action.

Fatigue has been mentioned by Guardione as a further source of injury, more especially in the case of workers engaged in unloading sacks the weight of which varies from 60 to 80 kg. Further, in emptying these sacks into the grinding machines the workers in question are obliged to mount a narrow and steep ladder. The weight of the sacks of powder varies between 75 and 82 kg. The transport of these sacks lasts throughout the whole of the working day (in 1913 from eight to twelve or even sixteen hours), and the work is effected during the greater part of the time in a very dusty atmosphere. Despite the fact that the industry is seasonal and that the sumac workers pass freely from one type of work to another, it is nevertheless true that the filling of the sacks is usually effected by workers who, on account of weakness or some affection of the respiratory system, are not suited for the other operations of a more or less tiring character. In the ordinary course of events the workers are in the habit of completing a series of operations passing from the loading department to the grinding department and thenceforth to the bagging rooms.

**Pathology**

Workers engaged in manipulating sumac do not in any wise suffer from the effects of the work even for a prolonged period, provided they have a good constitution. Delicate subjects, on the other hand, especially those with weak respiratory systems, commence to show symptoms from the first days onwards when engaged on grinding. At the end of a certain time the workers suffer from some discomfort which at times obliges them to remove the protective handkerchief and to go into the open air. These attacks of discomfort are more or less frequent in accordance with the constitution of the worker and the kind of life he leads. Those who remain thirty to forty years in the industry constitute exceptions, for even after a period of twenty-five or thirty years many workers are in poor health. Their general health is precarious and they are thin and pale.

Amongst 84 workers examined by Guardione the age-distribution was as follows: 22 workers were aged between twenty and thirty; 27 between thirty and forty; 16 between forty and fifty; 12 between fifty and sixty, and 9 between sixty and seventy.

Guardione has noted *nasal catarrh* generally accompanied by rhinitis which finally evolves into *hypertrophic chronic rhinitis*. The nasal secretion is very abundant, yellowish in colour and laden with sumac dust. Old workers in the industry have often a hoarse nasal voice and suffer from aphonia and chronic diffuse catarrh of the mucus of the larynx which on examination appears swollen and brownish red. The vocal cords are larger than normal. Respiratory lesions more or less serious in character affected 52 out of 84 workers examined, consisting in chronic bronchitis with abundant expectoration of yellowish matter (very numerous and clearly perceptible particles of sumac), pulmonary emphysema (24 cases) affecting chiefly the older workers, 6 of whom only presented the classical clinical picture of emphysema. This disease form is to be accounted for by the action of mechanical causes (dust, obstruction of the respiration by the handkerchief, undue effort of strain) and by trophic disturbance due to the particles of sumac. The alveolar lesions bring about trophic changes of the connective tissue and elastic fibres.

True pneumoconiosis has never been noted even amongst those who had worked in the industry for thirty years and upward, nor has pulmonary tuberculosis, and this fact is ascribed by certain authorities to the action of the tannic acid. No radiographic data are available.

Workers in the sumac industry are predisposed to respiratory disease which in their case follows a serious course and obliges them to cease work.

Pulmonary emphysema is often accompanied by circulatory derangements peculiar to this disease. Guardione has not met with disease affecting the other systems.

Of the family *Anacardiaceae*, the species *Rhus* are those which cause the greatest number of cases of skin trouble. The *Rhus cotinus* is said to contain a toxic alkaloid (phyllentine), the *Rhus venenata* a volatile alkaloid isolated for the first time in 1857 by Kihl; Maish and Pfaff, however, in 1864 are said to have found that this principle already active in 1/1000th mg. consists
of an acid which they have designated toxicodendronic acid.

The tropical varieties of the Rhhus genus, about sixty in number, and particularly the American varieties, are said to be more highly toxic and more highly irritant for the skin. They exert an action not only on the hands and forearms, but also on the face, the back of the neck and often on the whole body. The R. Toxicodendron (toxic or poisonous ivy) has caused, as sequela of the acute form, leucoderma. Serious forms have been caused by R. metopium or Jamaica sumac (Sumac Cardot) and by the R. Diversiloba (toxic or poisonous oak), and even fatal cases have been reported.

After a period ranging from a few hours to a few days of incubation, the part affected becomes covered with numerous vesicles accompanied by itching and a burning sensation. The phenomena disappear in general at the end of several days. In serious cases there is fever and paresthesia. The lesion may even evolve into a chronic form (Broers).

The occupational categories affected are agricultural workers, gardeners, etc.

The skin lesions caused by the different kinds of sumac are well known amongst the coolies working in the tobacco and rubber plantations, for instance, in British North Borneo. The Rhhus which causes this type of dermatitis is known under the name of Run gus or Ringus.

**Hygiene**

Grinding operations should be effected as far as possible in closed apparatus, and the transport of the powder to the various machines (sifters, bagging machines, etc.) should also be effected by mechanical means.

Measures of individual hygiene — working clothes, adequate cleanliness, wearing of respiratory apparatus, etc. — should be adopted.

**Bibliography**


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**Superphosphate Industry**

French: Industrie des superphosphates.
German: Superphosphatindustrie.
Italian: Fabbrica di superfosfati.
Spanish: Industria de superfósforo.

**Chemical Properties**

The fact that vegetables can only assimilate rapidly soluble substances led Gustav von Liebig (1840) to suggest rendering soluble (disintegration) of phosphate of lime (from bones) by means of sulphuric acid. The adoption of this method has resulted in an increased return from the soil due to the use of this new artificial manure (soluble phosphate of lime), and on the other hand has benefited manufacturers as well as farmers by giving them a means of utilising sulphuric acid in the manufacture of superphosphate fertilisers.

Superphosphate is prepared from natural phosphate of lime or of phosphate of bones. Deposits of tricalcic phosphate (CA₃PO₄) are fairly numerous in America (Florida, Tennessee, and Carolina), in Africa (Algeria and Tunis), in France, in Britain, in Canada, in Germany, etc. There are two principal varieties: phosphorite (the most abundant) and apatite (found in Canada, Spain, Norway, and Sweden).

**Industrial Manipulation**

Superphosphates are obtained by mixing thoroughly-ground tricalcic phosphate with a sufficient quantity of sulphuric acid to set free the largest possible quantity of phosphoric acid.

According to the quantity of acid employed, different proportions of monocalcic phosphate mixed with sulphate of lime are obtained. The mixture, which has become solid, is left aside for some time, then dried and stored. From the quantities of soluble and insoluble phosphoric acid and carbonates and silicates which the crude phosphate contains (these quantities vary), the chemist can calculate the strength and the quantity of sulphuric acid which should be used.

The manufacture of superphosphates entails the following operations:

(a) *Transport of raw materials and particularly of sulphuric acid.* — The only question of importance here is the use of sulphuric acid obtained from the acid chamber process at 53° B. When the sulphuric acid factory is very close to the superphosphate factory the liquid acid is conveyed thither directly in pipes. In this case an installation faultless from a technical point of view (stoppers, etc.) eliminates practically all risk.
For the transport of large quantities of acid, reservoir wagons are used; here it is necessary to take the greatest precautions against risk of explosion when they are emptied by means of pipes (see article "Sulphuric Acid").

Further, the manipulation of acid in an impurified state coming as waste from explosive factories not only involves a risk of explosion, but also the possibility of serious cases of poisoning (from nitrous gas, hydrogen gas, arsениуретттed gas). Reservoir wagons should, as far as possible, be emptied by means of pipes (see article "Sulphuric Acid").

It must also be remembered that a kind of sludge containing arsenic, and imbued with sulphuric acid, is formed in the reservoirs. In stirring up this sludge with the addition of water (in cleaning for example), a dilute acid solution is formed which gives off hydrogen (danger of explosion) and particularly arsениуреттт hydrogen (the cause of frequent poisoning).

Smaller undertakings often effect the transport of the acid in large glass bulbs which unfortunately are easily broken. This risk can be eliminated by the use of glass recipients covered with straw or basket work (carboys) transported in wagons or cars provided with shock-resistance devices and having a pipe worked by a lever for emptying and also devices assuring absolute safety for the operation of drawing off. Workers engaged on such operations should wear protective goggles.

For preliminary weighing it is necessary to use as far as possible automatic measuring and drawing-off apparatus.

For hygiene of the workshops, see articles "Industrial Hygiene" and "Acids".

(b) Breaking of crude phosphates.
— The crude phosphates, which according to the country of origin are in large or small pieces, have first to be broken up with a view to augmenting the surface which can be attacked by the acid. The breaking up of the raw material in a very dry state, and sometimes even calcined, is a fairly disagreeable operation accompanied by the production of thick clouds of dust.

Grinding by hand was the method first practised and was carried out in the open air, where possible under a roof affording protection from all winds to obviate the disagreeable effects from dust raised. The work was also carried out, however, in closed workshops where the dust was a veritable torment for the workers and干活ly endangered their health.

Grinding machines, provided with devices which completely envelop them and allow of mechanical loading by means of cranes, have now been adopted by the best-equipped firms. Improved conditions are guaranteed by using a ball grinder in which the dust produced in a closed space is conducted by a ventilator to a dust chamber and the ground product in a state of fine subdivision is led directly to the place of disintegration.

Though there is a lack of precise data in regard to serious affections proved beyond doubt as due to the dust of crude phosphate, it is commonly known that affections of the mucous membrane (eyes, nose, rhino-pharynx and respiratory passages) are set up. It is consequently advisable to eliminate dust production as completely as possible. In addition to the dust hazard, there is also a certain amount of fatigue due to the disagreeable noise of the grinding machines.

Hygiene. Grinding of crude phosphates should be done in closed apparatus preventing any escape of dust and provided with an effective exhaust device (having ducts leading to a dust chamber provided with a filter) in order that the workshop may be kept free from dust.

In Italy success has attended the installation of a system in which dust chambers are coupled together (cyclone system) and the rate of the air current is diminished. This system, however, is accompanied by less favourable conditions in the workrooms. It would be preferable to pass the air through cloth filters and refrain from reducing the rate of the air current. The flooring should be hard and compact; the workshops should have high ceilings and should be well ventilated and easily cleaned.

(c) Disintegration (mixing with acid).
— This operation, which consists in mixing thoroughly the crude phosphorus with the sulphuric acid, is inevitably accompanied by liberation of noxious fumes. The method of mixing in open trenches is very disagreeable for the workers and the neighbourhood, and has to-day given place to mixing in mixers connected with the superphosphate stores; this method allows of the heat generated during the operation being stored and utilised, and permits at the same time suppression of the noxious fumes.

The disintegrator consists of a closed kettle within which a wheel with wings or blades mixes thoroughly the raw
materials. The mixed product is then poured through openings with automatic closing into a "den" for storing the superphosphates — usually located directly below the disintegrator. Gases given off during the reaction (especially carbonic anhydride, sulphuric acid, hydrofluoric anhydride, and silicon fluoride) are drawn off by a system of pipes and chemically or physically converted before being liberated.

Amongst the noxious gases in superphosphate factories must be remembered hydrofluoric acid (see this article), the caustic action of which is immediately recognisable by the fact that the windows and electric lamps lose their polish after the lapse of a few days. Instead of discharging the fumes of silicon fluoride, acid gases, etc. into the upper strata of the atmosphere, it is much better to condense them and have them absorbed in refrigerating chambers and washed with water in towers (Korling system).

Condensation of silicon fluoride presents some difficulties, for the silicon produced is converted into a gelatinous mass. A method for long in vogue in Italy is the adaptation of a square tower inside which the gas passes from the top downwards and is withdrawn by water which falls in cascades over inclined "baffles". As the water leaves the fluosilicic acid and the gelatinous silicon it produces at the same time a current of air through the opening for charging the mixer where the disintegration of the phosphorite with the sulphuric acid takes place. This method of ventilation prevents any return of silicon fluoride or nitric acid fumes.

The waste water from the factory strongly impregnated with acid should not be discharged into watercourses without first being neutralised (with carbonate of calcium, for instance) or purified in some other manner. A thorough cleaning of all condensation and absorption apparatus should not be permitted except after effective ventilation, and the workers engaged on this work should be provided with respiratory apparatus since the incrustations formed in the walls and the flooring continue to give off considerable quantities of very caustic gas. Further, the uncovered parts of the body (face, hands) must be protected from contact with the hydrofluoric acid. According to certain authorities, these incrustations, which seem at first dry even to the touch, become activated as soon as they are displaced and give off fluosilicic acid which separates from the silicic acid. Consequently, it is advisable to pour potassium chloride over such incrustations with the object of transforming the fluosilicic acid into an insoluble hydrofluosilicate.

It is well to remember that with a modern installation the workers are not exposed to danger except where the machinery is defective from a technical point of view or where the operations are not effected in the appropriate manner.

(d) *Emptying the disintegration dens*. — The process of disintegration being over, the superphosphate produced is removed from the "dens" and thereafter dried and transported to stores (warehousing). Amongst the risks to which workers are exposed at this stage must be noted lesions of the skin and mucous membrane (eyes, respiratory passages) due to the caustic properties of the heated mass of superphosphates and poisoning from toxic fumes. On the other hand, carelessness in working may dislodge great masses of the product and give rise to very serious accidents.

Superphosphate "dens" should be emptied with all possible haste. As the product becomes more and more damp in course of cooling as a consequence of the condensation of steam, the workers are brought in contact with a product the temperature of which reaches 100° C. and over and are obliged to work in a hot and damp atmosphere. In addition to the risk of burns, the workers are exposed to damage from the hot and humid atmosphere, which hinders respiration, as well as from the presence of the noxious fumes referred to above which the finished product continues to set free in spite of the best adapted systems of ventilation. The wearing of respiratory apparatus of cloths or sponges over the nose and mouth reduces in fact the baneful action of the gas, but it impedes respiration and makes the work more and more burdensome to the workers engaged in narrow, overheated places.

The clearing out by hand of the "dens" is very difficult in practice even where the ceiling is high, because the free space left above the compact mass of the product is so restricted that it is impossible to attack the mass from the top. The workers have therefore recourse to a dangerous method, which consists in undercutting the mass in order to cause the top part to topple over. This method is one evidently liable to cause numerous serious accidents, often even fatal (fractures of limbs, crushing of the workers by
the fall of large blocks, or by the sliding down of the entire mass, and such accidents have not decreased since undercutting has been prohibited.

It has been held that such grave risks could be eliminated by increasing the space in the "dens", improving the ventilation and enforcing strict supervision. It must be recognised, however, that such precautions are not enforced or do not have the desired effect, and that the only adequate prophylactic measure would be the substitution of mechanical and automatic methods for manual labour.

When it is necessary for the workers to work in the "dens", the greater part of the noxious gases can be removed by an exhaust device which creates a depression favouring the withdrawal of dust towards the back of the mass of superphosphates.

With certain mechanical installations the workers have nevertheless to execute by hand the most important part of the work and are, despite such installations, exposed to the above-mentioned risks. The heads of undertakings and the chemists of the Association of German Manure Manufacturers replied in the negative (1921) to the question: "Does there exist an apparatus of proved application for emptying mechanically the disintegration dens?". This declaration had the happy result of stimulating a series of experiments and led to the discovery in the two following years of methods of emptying the disintegration "dens" under much more hygienic conditions.

The devices suggested (dredging devices) exercise on the porous but solid block of disintegrated superphosphates a cutting, hollowing-out, scraping or scratching action. The "dens" consist of recipients fixed or mobile in the form of vertical or horizontal vats. If the "den" is fixed, the emptying apparatus is hooked on above or at the side and made to penetrate to the interior. If on the contrary the "den" is mobile, it is transferred with its contents to the emptying apparatus which is fixed and which under these circumstances can be constructed in the "den" itself. The detached fragments fall on to travelling streets which convey them to other apparatus where they undergo the requisite mechanical transformation. The whole operation is carried out in a closed space; the gases given off by the reaction are withdrawn by the aid of powerful exhaust devices.

Modern apparatus have not only reduced the number of workers required to effect the operation in question, but have also eliminated almost entirely the risks which formerly accompanied this work. Further, in so far as regards the above-mentioned operation, the data furnished by the technical administration branches of superphosphate factories have once again proved that the improvement of health conditions implies improved economy and efficiency.

Hygiene. In the interests of the protection of the workers, the crude phosphate should be disintegrated in perfectly airtight containers. Every opening in such containers should be provided with closing devices which can be hermetically sealed. Before starting up the mixing machine, all openings of the container should be hermetically sealed saving only those serving to connect the latter to the mixing machine or for withdrawal of the gas produced in course of disintegration. These gases should be withdrawn by means of a powerful exhaust which should be set in motion before starting up the mixing machine. Emptying should be effected mechanically or, where this is not possible, all precautions should be taken to assure good ventilation of the working posts and of the "den". The workers engaged in emptying should have protection for the mouth and nose and should wear suitable shoes. Undercutting of the mass of superphosphates should be strictly prohibited. Highly acid gas from disintegration (about 5 grm. of sulphurous anhydride and 1 grm. of hydrofluoric acid per cubic metre of air) should not be allowed to escape directly into the atmosphere, and the waste water from the process of absorption and washing of the disintegration fumes (containing over 3 grm. of free acid calculated as sulphuric acid, and over 0.5 grm. of free alkali or alkaline earth calculated as caustic soda, not more than 0.05 grm. of arsenic and finally not more than 10 grm. of dry residue per litre) should not be allowed to escape into the subsoil or public canals or water courses.

(e) Drying and crushing. — The fresh superphosphate which becomes agglomerated in hard lumps and contains a certain quantity of water cannot be ground fine enough to satisfy the requirements of agriculture without first being dried. This operation, which improves the quality of the product, used to be effected in open hearths heated with coal or steam. Workers engaged near the heaps of superphosphate or occupied in shovelling the mass which continued to give off acid gases (especially fluor compounds)
worked under extremely trying conditions. This method is now replaced by a mechanical process effected with different kinds of drying stoves.

The addition of certain substances such as animal charcoal or bone meal accelerates the mixture and is effected mechanically.

The operation of crushing and sifting can likewise be carried out by the same apparatus as that used for drying.

The greatest danger here is presented by the gas used for heating and by the risk of accident.

**Hygiene.** The measures to be enforced in the interests of the worker and of the neighbourhood are the same as those cited above in section (d).

The workshops should be well ventilated, regularly and thorough cleaned at short intervals. The grinding and sifting should be done in closed and perfectly airtight apparatus provided with suitable and effective dust exhaust mechanism.

The manufacture of double superphosphate comprises the following operations; grinding of the raw material (phosphate), treating of the latter with sulphuric acid at 16-31° B., filtering through jute presses, concentration of the dilute phosphoric acid, mixing of the phosphorite with concentrated phosphoric acid (to obtain the double superphosphate), drying, and grinding of the finished product.

(f) Storing and transport. — Long-continued storing causes not only a chemical change in the product — which no longer has the same soluble phosphoric acid content (reversion to an insoluble state of the superphosphates) — but also agglomeration of the different particles which finally unite in a compact block. The latter must before usage be again ground and sifted. By reason of its hygroscopic properties, the superphosphate gives off relatively little dust; the occupational danger presented by dust therefore gives place to the much graver risk of accident to which workers are exposed in removing the product.

According to a report (1912) of the German Occupational Mutual Society (Berufsgenossenschaft), accidents are unfortunately unavoidable so long as shovelling is done by hand. The regulations for accident prevention prohibit undercutting of the mass when it exceeds two metres in height. According to the Industrial Hygiene Institute of Frankfort, however (1912), workers in factories are often allowed to engage in undercutting of terraces of two metres but constituting in their entirety a height of up to ten metres.

The terraces are cut away from below, cut into from the side, and large masses are suddenly dislodged and spring off with the aid of a hammer and wedge. It often, happens in such cases that considerable fragments detached from the upper part of the heap fall on the workers below or cause those working on the higher terraces to fall.

The masses of superphosphate are now sometimes even blown up with safety explosives, and experience has shown that this method is accompanied by a reduction of accidents so frequent formerly. The facts just recorded in relation to the breaking down of the heaps of superphosphates apply also to the storing and transport of sacks. The regulations prohibit more than four sacks being superimposed.

**Statistics**

There, unfortunately, does not exist important statistical data of incontestable accuracy relating to the health conditions of workers in the superphosphate industry.

**Pathology**

The workers in superphosphate factories are exposed to certain harm and danger of sickness due to the following causes: steam, undue heat during the reaction of the acid on the phosphate (especially while emptying the "dens"), caustic liquids, harmful and toxic gases and fumes such as carbonic anhydride, sulphurous anhydride, nitrous fumes (during treatment of phosphates with sulphuric acid with a nitric acid content), hydrofluoric acid, hydrochloric acid (during treatment with hydrochloric acid or the use of raw materials with a chlorine content), silicon fluoride (from the presence of fluorides of calcium and silica). In one fairly serious case, illness was due to nitric acid fumes given off by a mixture of saltpetre from Chile with superphosphates probably in a very acid state.

Besides cases of dermatitis reported in Germany and in Great Britain by the industrial inspectors and due chiefly to acid dust, there have been noted amongst workers engaged in emptying the "dens" cases of hoarseness lasting several days, and amongst workers engaged in drying operations purulent abscesses localised on the genital organs, due to soiled hands and arising, without doubt, during transport of hydrofluosilicate of soda. Cases of vertigo during the day and of over-excitement during the night were also noted amongst factory
workers who handled during the war sulphuric acid coming from an explosive factory (traces of nitro compounds).

In the Dutch superphosphate factories there was found 0.0035 mg. of hydrofluoric acid per litre of air (Ronzani see also article “Hydrofluoric Acid”).

The use of superphosphates causes amongst agricultural workers an irritation of the eyelids and of the conjunctivae, ulceration of the cornea with opacity and sometimes loss of the visual function.

LEGISLATION

Very detailed measures of protection for protecting the health and lives of workers in superphosphate factories have been given effect in Germany. The Federal Council, having decided to apply general regulations based on paragraph 1 of section 120 c of the Industrial Code, proceeded to undertake an enquiry in 1906, which revealed the fact that the majority of superphosphate factories were not engaged in the manufacture of this product for more than six or eight weeks in spring and in autumn (when orders are received from farmers). Since women and children were found to be restricted merely to inoffensive operations (sewing and marking the sacks), there seemed to be no ground for adopting measures of protection in respect of them. The conditions attendant on the grant of a permit for construction (section 16 of the Industrial Code) and the special provisions based on sections 120 and 120c were already found to afford the workers a large measure of protection. Though this enquiry (1906) did not lead to the issuing of any special order it stimulated, without doubt, a movement resulting in important improvement in the health conditions of the German superphosphate industry.

In general, women and children are excluded from superphosphate (lime and potash) factories where acid dust and fumes are given off; and young persons of 16 years of age in Belgium, and of under 18 years of age in France, and women of less than 21 years in Spain, are excluded from industrial work. For the other countries, exclusion is imposed under a more general formula applying to chemical manure factories.

Protection of the neighbourhood is provided in Germany by sections 16-25 of the Industrial Code. In virtue of section 10, the superphosphate factories are classed as “establishments which by reason of the situation or of the nature of their workshops may constitute a source of danger and serious inconvenience to the proprietors or inhabitants of neighbouring feus or to the public in general”. Their construction is consequently made subject to the grant of a permit from the competent authority, which is responsible for seeing that the regulations as to complete isolation of the factory, its construction, precautions against fire and in favour of hygiene, both as regards the work conditions and the workers in question, are given effect to. On 29 June 1896 the Occupational Mutual Society of the Chemical Industry published special regulations dealing with accident prevention in manure factories, regulations which were, however, superseded later by the “Regulations on Accident Prevention of the Occupational Co-operative of the Chemical Industry” of 1 January 1912, with appendices based on the typical accident prevention provisions of the Association of German Mutual Societies (Berufsgenossen- schafts-Verband). The provincial police orders and general orders of other authorities are in no wise modified by these provisions of the Occupational Mutual Society of the Chemical Industry.

Hygienic measures must further include the general precautions common to all unhealthy trades (cleanliness, effective ventilation, good lighting, etc.) as well as certain precautions peculiar to the industry in question such as: withdrawal of gas and fumes from apparatus and vats; special manipulation of acids and lye; special care in the cleaning out of apparatus, vats, “trenches”, etc.; protection from noxious gas fumes and dust in general; special precautions in cleaning vats provided with stirring apparatus or steam and acid ducts, and very special care when these have to be entered; effective precaution in working with masses of agglomerated material, and in storing sacks; enforcing of rules as to wearing of glasses, respiratory apparatus, special overalls, and footwear. The workers must be instructed in the dangerous properties of the gas and fumes to which they are liable to be exposed in this industry, in the precautions to be taken to prevent the gas and toxic fumes from escaping into the workshops, in the means of individual protection, in the cleaning of apparatus reservoirs and vats (especially from sulphuric acid), as well as in the special precautions to be observed when entering the latter.

Tracts and posters containing a brief account of the toxic properties of gas and fumes (arseniuretted hydrogen, hydrofluoric acid, carbon oxide, coal fumes, carbonic anhydride, nitrous gas, sulphuric anhydride, as well as the formation of explosive gases, etc.) should be prepared, distributed and posted up.

There exist special apparatus for determining the content of the atmosphere in gas and the nature of the gas liberated. The acid residues, waste liquids and other liquids must be completely neutralised before being thrown out and also deodorised where this is necessary; the gases should be condensed after being made to pass through columns of damp or oiled coke.

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Syphilis (Occupational)


Occupational syphilis is scarcely less common than the syphilitic manifestations of sexual origin. In some regions it is of even greater frequency than the syphilitic affections of genital origin. It was so notably in Russia under the former régime; there departments existed where genital syphilis was 9 to 10 per cent. of all cases and occupational syphilis 80 to 91 per cent. of cases (Popov and Beloussov, 1897).

The pathogenic agent of syphilis is the Treponema pallidum (Spirochaeta pallida); it is found in the lesions which may develop, so to speak, in any part of the body.

Outside the genital area, infection may occur by the intermediary of contact or by the intermediary of the most varied articles contaminated with syphilitic material, provided that the time which lapses between the contamination of the article and the time the treponema is not too long, as the treponema is rather a delicate micro-organism when outside the body. Hence infection is, in most cases, immediate, and only through abrasions of the skin and mucous membranes, even though quite minute.

Mention must be made of infection by the blood and urine of syphilitics, which contain treponemas, and so may form dangerous material. On the other hand, doubts exist as to the presence of treponemas in the milk of syphilitic women.

Statistics

The site of the lesion is most varied. According to some data collected by C. Ruhl in 1918, dealing with 11,829 cases of occupational syphilis described in medical literature, the primary manifestations were situated on the lips in 4,002 cases; in the buccal cavity, on the gums and on the tongue in 1,254; on the tonsils in 1,156; on the eye in 678; on the forehead, temples, ears and scalp in 151; on the cheeks, nose and chin in 691; on the neck, trunk, forearms and arms in 328; on the hands and fingers in 925; on the periungual region, the lower limbs, and the umbilicus in 180; on the perigenital region and the anus in 468 cases.

According to some figures, published by Henry Chabrol in 1925, based on cases observed at the St. Louis Hospital, Paris, during ten years, 1914-1924, out of a total of 11,518 syphilitic chancres, there were 690 cases of occupational chancres, or 6 per cent.

Chancres about the head were the most common; they claimed 79.3 per cent., of which 70.1 were about the mouth and 9.2 on the face. The distribution according to different areas was as follows: lips, 327; tonsils, 86; tongue, gums, palate and mucous membranes of the cheeks, 57; chin, cheeks and nose, 71; eye, 4; and scalp, 1.

Next follow chancres of the neck, trunk and limbs, which account for 88 cases out of the 690, or 12.8 per cent.; hand, 27; forearm and arm, 2; pubes, breast and thigh, 43; toes, 2; groin, buttocks and abdomen, 12; and neck, 2. Then come chancres of the anus and the perineal region, amounting to 56 cases out of the 690, of which 17 were in men and 39 in women, giving 8.02 per cent.

As regards localisation on the fingers, it has been found to account for about 4 per cent. of occupational chancres and 0.25 per cent. of syphilitic chancres in general. The method of contamination in these cases was either venereal (18 out of 59), or due to occupation (4 cases), or to traumatism or accident (5 cases), of which 5 were bites (G. Bienfait, 1925).

Occupational Pathology

Extra-genital syphilis of occupational origin is met with chiefly among:

(1) Medical personnel (doctors, midwives and nurses). To this category belong all forms of syphilis, whether occurring among doctors treating syphilitics, surgeons, gynaecologists, dentists and laryngologists, in whom, in most of the cases, the lesion is situated on the fingers or the hand; more rarely, it occurs on the face, particularly when the patient suffers from an open syphilitic lesion and coughs or spits at the time of the examination (Desmarres in 1854 and Le Loir in 1866).

As regards localisation on the face, it is still a matter of dispute as to whether a hand soiled by virulent material can possibly carry infection to the nose or eye (Boucheron in 1866; Buret in 1892; Hutchinson in 1879).

Localisation on the eyes and surrounding parts has been reported by Alexander, following upon irrigation carried out on a syphilitic patient, and by Enslen and Schweinitz, following the projection of amniotic fluid containing syphilitic virus into the eye.

Truβ has collected 300 cases of
syphilitic infection among doctors as the result of their work. According to Hallot, the number of occupational syphilitic chancres among doctors, as shown in all literature up to 1924, reached 530. Djeumitsky and Slanko in 1929 received 314 replies to a questionnaire on the subject of occupational syphilis sent out to doctors, in this way they learned of 43 cases, to which were added 8 cases published after the enquiry. Of these 43 cases, 24 were investigated at Kharkov and the persons affected were doctors in 25 cases, 2 of them being women; dentists in 2 cases, one being a woman; hospital attendants in 10; midwives in 10; and nurses in 4, 2 being women. The predominance of the lesions among men has been explained by the fact that women less frequently specialise in the occupations involving exposure to the contagion. Among the latter, the infection occurred 17 times from attending confinements, 10 from giving syphilitic treatment, 6 after gynaecological operations, and 5 after surgical operations. The situation of the lesion was in 29 cases out of 4 on the fingers, i.e. 67 per cent. Among the 25 doctors infected, the development was serious in 11 cases.

Metschersky and Olesoff in 1929 reported 5 cases of typical occupational syphilis, and Dujardin in 1932 reported 2 cases (a gynaecologist and an ear and throat specialist: infection on the fingers). The occupations of the infected persons were: doctors and pathologists, 14; dissecting-room attendants, 6; and laboratory attendants, 2. The course of the disease thus contracted has often been serious.

(2) Wet nurses who feed congenital syphilitic infants. The lesion is situated on the breasts and chiefly in the areolar regions. But there have also been noticed in wet nurses and nursemaids who have charge of infected children, buccal and lingual lesions, due to either kissing the infant, or to the habit of putting in the mouth the teat, or the spoon with which the infant has been fed. Lesions have also been observed on the eyelids, due to contact with a pillow on which the infant has dribbled (Pellizzari, 1862); and on the forearm, due to carrying infants having syphilitic lesions in the region of the anus.

(3) Glass-blowers. In consequence of passing the blowpipe from one workman to another, the lesion is naturally situated on the buccal mucous membrane. With glass-blowers the mucous membrane is very often found in a chronically inflamed state, with excoriations and rhagades produced by the pressure of the blowpipe on the lips and gums; they thus facilitate the entrance of the virus. Some small epidemics of this kind have been reported: at Milan (6 workers; Bernacchi, 1910); at Florence (Mibelli, 1920); to which should be added epidemics which occurred some time ago at Rive-de-Gier (20 cases, Violleau, 1962) and at Montluçon (30 cases, Dechaux, 1868-1869). There is also mention in literature of 82 cases of syphilitic infection reported in the records of the hospital of Antiquaille at Lyons (1858-1872) and of cases described by Ravogli and Rasori (Italy 1880), Siegmund (4 cases, Austria, 1863) and Heiberg (9 cases, Denmark, 1883).

Medical supervision on the one part and propaganda relating to sexual hygiene on the other part, but chiefly the introduction of mechanical technical methods, have much reduced and almost eliminated this danger.

(4) Goldsmiths may be affected in consequence of the use of the blowpipe. This danger is much less common; the only cases known are 3 situated on the lips, described by Margoniner in 1863.

(5) Workers in various other occupations. These cases are very rare; but mention may be made of the following, drawn, for the most part, from old authors: infection caused by the use of signal whistles by several railway
guards (Gross, 1874; Taylor, 1890); by musical instruments used by several persons — a cornet (Sigmund, 1863), a clarinet (Pospělov, 1889), and a flute (Vigüier, 1888). Lesions on the lips or tonsils have also been observed in chefs who have tasted dishes with a spoon which had been used by an infected fellow chef (Jullien, 1886; Tschistiakoff, 1890).

Furriers (3 cases) have been infected in consequence of the habit of biting threads with the teeth (Poray-Koschitz, 1889); shoemakers and upholsterers from holding between the teeth before use nails which have been infected previously by syphilitic workmen addicted to the same practice.

Occupational infections have been described among cashiers infected by coins and bank-notes (Desnos, 1889; Fitzgibbon, 1889; Robinson, 1884), among laundrymaids and housemaids from contact with infected linen (Boeck, 1875; Dornig, 1885; Guntz, 1883; Neumann, 1888); among rag-pickers (Fourrier, 1885) and also, as quite an exceptional case, a police officer bitten in the exercise of his duties by a syphilitic prisoner (Finger, 1926).

Injuries may activate a latent syphilitic infection and cause syphilitic lesions to appear at the point of injury. Klander reports the occurrence of cutaneous gumma, and of gumma of the testicle due to this cause. According to Diez, the relation between traumatism and syphilis can be summarised as follows: inoculation of the spirochaete can occur through wounds received from causes inherent to work; injuries caused by accidents in syphilis may lead to atypical and serious developments of the disease, setting up sequelae which do not occur in normal subjects; as a consequence of accidental injuries affecting syphilitic subjects tertiary conditions may become manifest in the injured parts.

Barthélemy considers that, while the occurrence of post-traumatic syphilitic conditions is a fact, it rarely happens. Before accepting or rejecting post-traumatic syphilis, the circumstances of the accident must be rigorously established, and the syphilitic nature of the lesion must be placed beyond possible dispute. Pedes and Donnadieu in 1928 described a case of syphilis of this kind in a working painter who was wounded on the thumb while taking out the panel of a door: the authors draw attention to the fact that it is far fetched to attribute the condition to an occupational origin. Michael considers that traumatism only rarely leads to the development of tertiary syphilis or of para-syphilitic lesions.

Prophylaxis

Prophylaxis against occupational syphilis, although essentially simple, presents in practice notable difficulties, especially from the impossibility of always recognising the existence of the disease. Ignorance concerning infection plays the most important part in contagion. On account of this it is necessary to insist ever more and more on the practical rules of personal hygiene which protect the worker from contagion. In addition to that, stringent methods of diagnosis should be used in all cases in which doubts may exist. This is notably the case with wet nurses, where serological examination of a possible carrier of the virus should be almost obligatory. Amongst workmen, and in hospitals, it is necessary to prevent as much as possible the promiscuous use of all objects which may serve to transmit syphilis. On all occasions when instruments or materials are used, which are capable of transmitting the virus, the rule must be adopted of providing separate instruments or materials for each person, and, in this way, of avoiding the passage of an object from one worker to another. As regards medical personnel, all precautions must be taken during the examination of syphilitic patients or when handling infected materials. India-rubber gloves should be worn, and protective arrangements against the projection of such infected materials as expectoration, pus, or blood, should be made compulsory in all cases in which there is danger of infection.

Legislation

Occupational syphilis in midwives, doctors and nurses is compensated in Bulgaria; and in Mexico for glass-blowers where the primary chancre is buccal, and for the sanitary service where the primary condition is on the hands. It may also be so compensated in countries which have adopted the general formula of "infectious diseases" for the sanitary service. See articles "Infectious Diseases" and "Medical and Allied Professions".

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Talc


Talc is a silicate of hydrated magnesium \((\text{Si}_4\text{O}_{12}\text{Mg},\text{H}_2)\) which is found in stratified compact masses with varying colour aspects (white, green, brown, rose), varied structure (earthy fracture, translucid and mother-of-pearl-like sheets) and varied hardness. When the structure is slightly fibrous and translucid it constitutes the soapy variety known as "steatite" which gives a white powder oily to the touch.

Talc is almost completely acid-resistant; it absorbs and retains perfumes well. Talc powder is a perfect lubricant for the skin, for which it forms a protective coat against irritation due to friction. It has replaced starch for all hygienic purposes.

Artificial talc is obtained by treating the solution of a salt of magnesium, the precipitate of which is washed and dried with silicate of soda. Talc extracted from quarries in more or less bulky form, is submitted to a first process of sorting, which has for its object the removal of grey or green pieces coloured by iron impurities and thus rendered unsuitable for hygienic purposes. After drying in the sun (or artificial drying) and crushing, the talc powder is passed through a series of sifting machines of increasing fineness, furnishing a series of powders of varying grades.

Talc is used as a loading material in the paper and cardboard industry; as a substitute for kaolin; in the textile industry for dressing material and as a lubricant; in the rubber industry; in the preparation of rice-powder, etc.; in the manufacture of small gas and acetylene jets, etc.; in the glass industry for the manufacture of opaque glass; in the colour industry for the manufacture of pastels; as a lubricant for gloves and shoes; for the manufacture of sealing wax; in the perfume industry (impalpable powder) for the preparation of rice-powder, etc.; and as a loading material in soaps, shampoos, creams, etc.

It was Thoral who was the first to describe in detail in 1896 a case of talc pneumoconiosis which he designated under the name of "steatosis" (Specksteinlunge).

The second case, particulars of which were not published, was studied by R. Sand in 1910. It was the case of a woman worker who had worked during several years in an atmosphere rich in talc and who died from a disease contracted during that time. The microscopic preparations of the lungs showed countless talc particles in the alveoli and in the conjunctival tissue, but without great reaction (communication by the author).

In the report on pulmonary diseases due to dust presented at the National Congress on Occupational Diseases at Turin in 1911, Devoto and Cesabianchi referred in detail to the case of Sand, drawing attention to the fact that it was a question of a dust so far considered as harmless, but which, on the other hand, was capable of setting up a slow inflammatory process of chronic and sub-acute nature, yet extending to almost the whole lung, the lesion having even attacked here and there in the case studied the pulmonary alveoli.

A third unpublished case studied clinically and radiographically by Cunningham, of Toronto, relates to a worker who from the age of nine was employed in grinding talc. Cunningham noted typical lesions of pneumoconiosis. In 1931 Zaneli described a fourth case. It was that of a woman worker aged 27 who during five years had been employed in introducing by means of a jet of compressed air large quantities of talc into the inner tubes of bicycle tyres and who also cleaned the exterior surface of these. This work was done in the absence of all
Tantalum, a rare metal less abundant in the earth's crust than gold. It is found in combination with some rare ores (especially niobium), in tantalite, or niobite, melanocerite, samarskite, etc.

Tantalum is obtained from tantalites by melting the ore with potassium dichromate. The product in aqueous solution is brought to boiling point and the residue, consisting of tantalum acid and niobic acid, is treated with hydrofluoric acid to obtain soluble fluorides of tantalum and niobium. Tantalum, a precipitate of the solution from the fluoride of potassium, in the form of fluoride of tantalum and insoluble potassium (the niobium remains in solution) is treated with sodium. The metallic tantalum obtained is in the form of grey-black powder, which is purified by melting in the voltaic arc or in a vacuum. Tantalum is highly resistant to corrosion by chemical agents, except by hydrofluoric acid, which however acts very slowly, and has the highest melting point of all the metals.

Tantalum may be worked in a cold state, drawn, forged, manufactured, polished, hardened, rolled and stamped. The pure metal is still more easily worked.

At the present time tantalum is used in the manufacture of lamps and tubes for the vacuum process, particularly in the radio-electric industry; in the manufacture of certain alloys, of apparatus utilised in the spinning of artificial silk, of coverings for apparatus intended for the chemical industry, in making pen nibs, in the preparation of supplies for use in dental prosthesis, and in the jewellery trade. It is used as a substitute for platinum in making electrical apparatus (electrolytic valves for electrolysis, etc.). In view of the fact, however, that it absorbs a certain quantity of gas as soon as it is brought to a temperature exceeding 350°C, thereby suffering a diminution of its mechanical properties, tantalum will never be very extensively utilised.

No injuries of an occupational character which can be ascribed to tantalum are known.

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**Taxidermist**


Taxidermists — those engaged in stuffing animals for trade purposes or naturalists — prepare the animals with a view to their conservation in their natural-state. Animals recently killed, and as clean as possible, are skinned in such a manner that the tegument should not be destroyed and that the skin, fur, feathers or scales which cover it may be preserved intact. This opera-
The skins are then treated with various products applied with a view to their conservation: boricur soap, Brown's solution of chloride of lime, a solution of corrosive sublimate and mixtures containing tannin and calcined alum, etc.

The cleaning of feathers and fur is also effected by rubbing with a wad impregnated with petrol spirit, and thereafter powdered over with plaster of Paris, which is removed when the fur is dry by means of beating with a feather brush.

The skins, after preparation, are stuffed with straw. in order to give them the form of the body, and the heads are finished by insertion of artificial eyes, etc. At the present time a process of modelling is followed (wood, plaster, cork conglomerate, etc.), which consists in applying the skins to models of the animals prepared in advance.

A Chicago taxidermist has provided a description of the method followed by him in preparing the arsenical solution. He mixes about a pound of white arsenic with 4 parts of water, to which he adds soda, boiling the mixture in the open air until it is dissolved. Into this he plunges the feathers of birds, which he applies while still wet to the straw form or model of the animal. The skins of animals are first treated with salt and water, and after with the above arsenic solution. This expert believed that the arsenic did not act as a skin irritant until the moment at which it became dissolved. He had never suffered from cutaneous symptoms during his long experience as a taxidermist (Hamilton).

Nevertheless, troubles of a specific nature are numerous: cutaneous eruptions, ulceration — mostly situated on the fingers, and recalling the ulceration observed amongst tanners and furriers — lesions of the nails, general symptoms caused by preparations with an arsenic or mercury basis. Barton, quoted by Kobert, has found a typical arsenic neuritis affecting a taxidermist and his wife. The Browne solution prepared where not, fumes which irritate the respiratory and ocular mucous membranes. The possibility of workers engaged in stuffing animals becoming infected as a result of handling skins contaminated with anthrax spores must not be overlooked.

Layet had already in the past drawn attention to the fact that time spent in workrooms containing collections of stuffed animals was likely to endanger the health. The preserving media, having dried and been reduced to dust after the passage of time, became disseminated in the atmosphere, and, after inhalation, were capable of setting up, after some time, symptoms of chronic poisoning.

Arsenic poisoning amongst taxidermists is subject to compulsory notification in the Netherlands; mercury poisoning entitles victims to compensation according to French legislation; compensation is likewise granted in those countries which have a schedule containing the general formula adopted under English legislation (see article "Occupational Diseases: Definition and Compensation").

### Tea and Coffee

**French:** Café, Thé. — **German:** Kaffee, Thee. — **Italian:** Caffé, Te. — **Spanish:** Café, Te.

#### Coffee

An investigation carried out by the Institute of Tropical Medicine of Porto Rico in 1913 ascertained that ascariasis (parasitic disease due to ascarius lumbricoides) was the prevailing disease among coffee workers. Ninety per cent. of 10,140 persons of all ages and both sexes were found to be affected. Nervous symptoms were usually absent, but gastro-intestinal disturbances were common and often very serious. Two serious effects of ascariasis were noted: (1) the upward wandering of worms, causing vomiting, penetration into gall duct and liver or perforation of bowel through a pre-existing ulcer, and (2) intestinal obstruction and abscesses in certain organs. Trichuris trichuria and strongyloides stercoralis are also common in Porto Rico.

Observations based on a three years' study of conditions on Guatemalan coffee plantations have revealed the following facts. The plantations occupy an intermediate temperate zone between 600-800 m. On the Atlantic side the kolono system is in force, that is to say, the labourers get land unsuitable for coffee growing to grow cereals in return for six to twelve days' work per month on the coffee plantations. Under this system conditions were found to be fairly favourable. Many plantations on the Pacific side, however, are not worked on this system, the labour-
ers working full time on the coffee plantations and living in hutments poorly supplied with water. Part of the labour required is imported from the higher land and the movement of population favours the spread of contagious diseases. Diet is poor and alcoholism prevalent. Pneumonia is rare and malaria unusual, but amaebic dysentery is widespread, sometimes sporadic and at others epidemic. A number of cases clinically T.B. were seen, but acid-fast bacilli could not be found and it was suggested that these cases were bronchomyocosis. The course of tuberculosis is one of months rather than years. Widespread alcoholism was found to cause hepatic cirrhosis, death from acute alcohol poisoning, pneumonia, and to give rise to bad dieting, bad housing and much social misery.

Cort, Riley and Payne investigated conditions at Porto Rico to determine the relation between coffee growing and the incidence of ankylostomiasis. Thanks to hygienic improvements and treatment it was found that infection after being extremely widespread amongst workers on coffee plantations has greatly diminished. The soil of these plantations offers an extremely favourable medium for the development of larvae, rain acting as a direct agent for propagation of eggs and larvae. Though living conditions of the coffee workers, unprovided with sanitary conveniences, contribute greatly to the spread of infection. Only by a well-organised scheme of prophylaxis can this disease be prevented from spreading. Trachoma was likewise found to be of frequent occurrence.

**STATISTICS**

Mortality rates on Guatemalan coffee plantations were distributed as follows: 22 per cent. from intestinal parasites, 22.5 per cent. from affections of the intestinal tract, 13 per cent. from affections of the respiratory system, 30 per cent. from acute infectious complaints, chiefly influenza; mortality from amaebic dysentery in an epidemic reached 6 per cent. In 1923 tuberculosis caused 7.7 per cent. of the hospital mortality and in 1924, 6 per cent. (For reference to prevalence of fatal accidents due to serpent and snake bites, see article "Native Labour").

**PATHOLOGY**

Coffee poisoning is widespread in all the coffee-drinking countries. As regards occupation it is most frequently met with amongst students, literary men, orators and the working classes (on the Continent), especially among women: cooks, charwomen, dressmakers and washerwomen, etc.

Nervous symptoms affecting coffee tasters should also be mentioned (see below under "Tea and Coffee Tasting").

**HYGIENE**

Prophylaxis in regard to these diseases which attack the workers in the coffee plantations must be along the lines of the application of certain general and special hygienic precautions (housing, anti-ankylostomiasis campaign, etc.) as already described in preceding articles, for instance "Agricultural Workers, Pathology of", "Ankylostomiasis", etc.

**Tea**

The following results have been revealed in an enquiry to ascertain proofs of health improvement following the adoption of hookworm control measures on Ceylon tea estates. Of 985 coolies examined 99.2 per cent. were found infected with helminthiasis. Carbon tetrachloride was administered to all on the estate and repeated after a year. Reinfection during the first year was to the extent of 20 per cent. of the average original infection and in two years rather less. In another investigation of coolies on Assam estates examination showed an incidence of 93.6 per cent. for hookworm infection. Napier and Foster have studied the incidence of Kala Azar amongst the coolies on the Indian tea plantations (1927).

**TEA AND COFFEE TASTING AND DRINKING**

Tea tasters sit at revolving tables with several samples of infused tea before them. These are sipped to determine the aroma. The taster then rinses his mouth and expectorates. Despite this, owing to continued tests, more or less of the beverage is swallowed and absorbed and may produce chronic intoxication symptoms varying with dosage and individual susceptibility, but mostly characterised by loss of appetite, gastric catarrh, flatulent dyspepsia, constipation, insomnia, irritability, restlessness, muscular trembling, gradual emaciation, and in some cases discoloration of the nails. People who over-indulge in tea or coffee suffer from similar symptoms.
Telluretted Hydrogen

Telluretted hydrogen (formula H₂Te) is a colourless gas with a nauseating smell, recalling somewhat sulphuretted hydrogen and arseniuretted hydrogen. Of high specific gravity it dissolves in water. The solution is relatively stable, but unstable in alcohol.

The gas itself easily becomes dissociated, precipitating tellurium in a black pulverulent form. It is very active chemically, very toxic as are tellurous and telluric acids, their anhydrides and salts.

Once inhaled the gas undergoes dissociation inside the body and tellurium is found in all parts deposited in the cells so that the organs look grey (see the article "Tellurium").

The symptoms of poisoning resemble those of seleniuretted hydrogen. Headache, malaise, weakness, vertigo, respiratory and cardiac symptoms come on after a few minutes after inhalation.

When there is no acute but only chronic poisoning the single symptom — and a very disagreeable one (present also in acute poisoning) — is a strong alliaceous smell of the breath and skin secretions. This symptom may persist for weeks after the poisoning is over (ten weeks in one case). According to Mylius, quoted by Egli-Rüst, absorption of one milligram of telluric acid, or manipulation merely resulting in re-absorption by the skin, suffices to bring on this symptom.

Egli-Rüst reports two cases of intoxication affecting chemists (Oppenheim, Wöhler) and two others in the course of melting spongy platinum derived from minerals containing tellurium.

According to Lewin, symptoms of poisoning have been observed in the course of therapeutic use of basic nitrates of bismuth containing tellurium. It requires only five ten-thousandths of a milligram of bioxide of tellurium to communicate to the breath the smell of garlic.

Tellurium


Chemical Properties

Tellurium (Te), discovered in 1782 and isolated as an element in 1798, was little known until recently, when it was found to be a constituent of the sludge deposited in the electrolytic cells in which copper is refined. This sludge is first treated to
recover the more precious metals, and the residue subsequently to obtain tellurium. It occurs free, in a crystalline state in small quantities in certain minerals, but is more frequently found combined with gold, silver, selenium, or iron. The chief sources of tellurium are tetradymite \((\text{Bi}, \text{Te})\) (bismuth sulpho-telluride); altaite \((\text{Pb}, \text{Te})\); coloradoite \((\text{Hg}, \text{Te})\); calaverite \((\text{Au}, \text{Te})\); sylvanite \((\text{Ag}, \text{Au}, \text{Te})\); petzite \((\text{Ag}, \text{Au}, \text{Te})\); and nagaugite \((\text{Au}, \text{Pb}, \text{Te})\) \((\text{Te} \cdot \text{S} \cdot \text{Sb})\). Native tellurium \((\text{Te}_2\text{O}_3)\) or tellurium ochre is also found. About 17 per cent of tellurium is extracted from the red sulphur of Japan.

Tellurium is a bluish-white, silver-like element with a metallic lustre, with atomic weight of 126.6. It melts at 452°C. When cooled from the molten state it forms hexagonal rhombohedral crystals; when heated in air it burns with a blue flame, forming tellurium oxide \((\text{TeO})\). Tellurium is not attacked by hydrochloric acid, but reacts readily with nitric and sulphuric acids and concentrated caustic potash. Its physical properties resemble those of the metals, but in its chemical properties it is decidedly non-metallic. It forms two oxygen acids: tellurous acid \((\text{H}_2\text{TeO}_3)\) and telluric acid \((\text{H}_2\text{TeO}_4)\), and a number of salts can be prepared from these acids (tellurates of sodium, potassium, cerium, mercury, zinc, copper, silver, etc.). Tellurides or alloys of the metals with tellurium can also be prepared. Halogen compounds (two chlorides, bromides, and iodides of tellurium) are known, as well as several organic compounds.

**Production**

Tellurium may be extracted from minerals or recovered from the sludge in metallurgical processes (electro-refining of copper, lead, and other metals). After recovery of the more valuable metals in electro-refining, the residue is subjected to repeated lixiviation with hydrochloric acid; it is then filtered, and the resultant bright yellow filtrate is treated with sulphur anydride to precipitate the tellurium. On driving off the hydrochloric acid by evaporation, additional precipitation occurs, and further precipitation still on addition of sodium bisulphite. Subsequent heating will cause another precipitation. It is obtained from bismuth telluride by mixing it in a finely powdered state with sodium carbonate; rubbing with oil to a stiff paste; calcining in a closed crucible; lixiviating with cold water, and blowing a current of cold air through the aqueous solution of the resultant sodium telluride, when the tellurium separates out as a grey powder.

**Uses in Industry**

Tellurium is not as yet used to any great extent in industry, but much research, with a view to more extensive application, is in progress. In the glass industry it is used to give a blue, red, or brown colour in glass. Owing to its reducing properties, tellurium has been experimentally utilised in the iron and steel industry in the same way as coke and has also been found useful in revealing the presence of bacterial life.

**Toxic Properties**

The possibility that tellurium might act as an industrial poison was first mooted in 1918 during an enquiry into lead-poisoning in an electrolytic lead refinery, when it was noted that the breath of all workers in a certain department smelt strongly of garlic, though none of them had eaten it. Many of them complained of a dry skin and arrest of perspiration. The symptoms in question could not be attributed to lead poisoning, and further investigation proved them to be confined to the workers who had been in contact with tellurium, in the silver refinery, working at the furnaces at very high temperatures (700 to 760°C.) and where there was exposure to the fumes and dust of tellurium. These fumes were probably in the form of hydrogen telluride, a compound analogous to hydrogen sulphide and arseniuretted hydrogen, and tellurium was also present in the furnace dust probably as oxide and telluride. Sodium telluride is one of the most powerful haemolytic poisons.

In animals small doses markedly reduce the secretion of acid in the gastric juice and stimulate secretion of gastro-intestinal mucus (this being apparently due to paralysis of the secretory nerve endings), while the capillaries of the splanchnic area are dilated. In acute cases there is vomiting, weakening of the reflexes, tremor, somnolence, and death from asphyxia in tonic and clonic convulsions. Before death, intense destruction of the red cells with diminution of the amount of haemoglobin, presence of myelocytes, normoblasts, and sometimes considerable leucocytosis. Large quantities of urobilin, together with haemoglochin, are usually detected in the urine, and in many instances a large quantity of some reducing substance; this is thought by some observers to be sugar and associated with hypoglycaemia and differing from ordinary glycosuria, while others deny that there is glycosuria. Post-mortem examination reveals disintegration of the mucus membrane of the gastro-intestinal tract; intestinal haemor-
rhages; also intense hyperaemia of the organs, and multiple haemorrhagic foci. Large doses produce some albuminuria due to parenchymatous nephritis. Certain authorities, however, are of opinion that there is no evidence of urobilin in the urine, a sign that the liver is functioning well, and this, they say, is borne out by histological findings which reveal but rarely lesions of this organ.

The main channels of entry into the system are the respiratory and alimentary tracts. Marvin Shie and Forrest Deeds believe that salts of tellurium are probably absorbed through the skin. This channel of entry is characteristic of tellurous acid, as, shortly after handling tellurous acid, the garlic-like odour of methyl telluride appears in the breath. A workman, who had collected with his fingers tellurous anhydride that had fallen into a vessel, absorbed sufficient of it to give the garlic-like smell to his breath for a week, and to have a bitter taste in his mouth for 48 hours. A single dose of 0.13 grm. of tellurous oxide, taken experimentally, has sufficed to impart the taste of garlic for two and a half months.

After entry into the system, salts of telluride are reduced to metallic tellurium, forming a methyl telluride which is very volatile, and gives a peculiar garlic-like odour to the secretions and excretions. This formation of methyl telluride is one of the rare cases in which a compound of methyl is formed in the animal body.

The greatest toxic effects are produced during the reduction of the salts. Elimination takes place in the faeces in metallic form; and in the exhaled breath, urine, faeces, and dermal secretions as methyl telluride; and in small quantities, in the bile and urine, in soluble form.

A minority of writers hold the view that tellurium is non-poisonous, but admit that its oxygen compounds, even in small quantities, form dimethyl-telluride in the human body, that they are slightly poisonous, and that hydrogen telluride changes immediately to black telluride when in contact with the moist mucous membrane and has a slight irritating action.

Despite the fairly mild symptoms recorded, the fact that these may have important secondary effects must not be lost sight of. The inhibition of the sweating function renders the persons engaged on furnace work and subjected to very high temperatures, especially in summer, very liable to heat exhaustion, and the inhibition of the secretion of saliva and other digestive juices is liable to bring about lasting digestive disturbances.

Statistics

No severe cases of poisoning have so far been reported. Of thirteen workers examined in a department bringing them into contact with tellurium, seven showed evidence of absorption. Five of these suffered from inhibition of the sweat function (the two who did not had only worked for two weeks). Three workers who had been employed only a short time had dry itching skin, anorexia, nausea, vomiting, depression, and somnolence; eight foreigners were unable to answer questions. Probably if an interpreter had been available symptoms of tellurism would have been discovered among the last mentioned. Mention should also be made of an experimenter who, after having been engaged in melting tellurium in the open air for several hours, slept for no less than 18 hours on end.

Symptoms

Up to the present, the early symptoms noted in man in acute poisoning, even after absorption of small doses, are garlic-like odour of breath and somnolence. Other symptoms are: garlic-like odour of the sweat and the faeces, dryness of mouth, nausea, vomiting, metallic taste, depression, constipation and diarrhoea, and suppression of the sweat functions. The skin becomes harsh and dry, and pruritus often results.

In cases of chronic poisoning the symptoms are retarded digestion, vomiting, loss of appetite, emaciation, and somnolence. Mild tellurism produces the same effects in man and in animals, and it may be expected that the more severe effects will also be similar (see above). Certain authors draw attention to the absence of jaundice as a symptom.

Diagnosis

Such after-effects resemble those produced by absorption of arsenic, antimony, selenium, and lead, and as these metals are almost always present with tellurium industrially, an exact determination of the source of these effects is rather difficult. Three symptoms, however, are distinctive of tellurism: suppression of sweat, dryness of mouth, and garlic-like odour of secretions. Ingestion of arsenic may give a garlic-like odour also, but much fainter than that produced by tellurium and requiring a very much larger dose to produce. Analysis of the urine and faeces may have to be resorted to in doubtful cases.
TESTS FOR PRESENCE OF TELLURIUM

Acid sodium sulphite indicates presence of tellurium in solutions containing as little as 0.00000004 grm. per cent. of tellurium. It is treated with hydrochloric acid with as little chlorine gas as possible, then heated to expel the chlorine. Acid sodium sulphite is added to the solution which is then filtered, leaving tellurium as a black precipitate on the filter paper. Tellurium heated on charcoal gives a white sublimate of tellurium which is volatile, and when in contact with a reducing flame imparts a pale greenish colour to it. If heated with concentrated sulphuric acid it gives a deep crimson colour to the solution, which disappears if the acid is too hot or is diluted with water after cooling.

HYGIENE

Measures of prevention are those generally to be adopted against metallic dusts and fumes: adequate natural and artificial ventilation, removal of fumes at the point at which they are produced, provision of respirators for men engaged in cleaning flues, adequate drinking and washing facilities; personal hygiene. Particular care should be observed in summer when the danger of heat exhaustion is greatest, and strict medical supervision of workers should be provided, with power to the surgeon to suspend from work on the appearance of early symptoms. No special measures have been adopted up to the present.

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Temperature (High and Low)

The temperature of the surroundings in which an individual lives or works exerts a very definite influence on the functions of that individual. These functional changes vary according as the temperature is very high or very low; but to establish the point at which the said influences begin to manifest themselves is not easy, for they are closely associated with other factors, and in particular with sharp variations of temperature, especially as related to the degree of humidity and movement of the air. It can, nevertheless, be asserted that the ideal temperature at which the body does not suffer in any of its functions is at 20° below that of the human body in its physiological state. Admitting that the temperature of the human body under normal conditions varies between 36.5° and 37° C. the optimum surrounding temperature will be between 16.5° and 17° C.

The body tolerates quite well for light occupations temperatures which depart to a certain extent from this point. This is not, however, possible, as has already been said, to fix the limits at which heat and cold begin to exercise a pathological effect, because, in addition to the factors already mentioned, such as sharp variations, the degree of the humidity and of ventilation, the resistance of the individual plays an important part, it being itself modified by pre-existing physical defects. Thus, all conditions being equal, patients suffering from arteriosclerosis, kidney or heart disease, or emphysema are more sensitive when the surrounding temperature departs from an optimum point which, as stated, varies between 16.5° and 17° C.

In order to understand changes in resistance to heat and cold some physiological facts must be recalled.

A man in good health has an internal heat of about 37° C. whatever the temperature of the external surroundings may be; this arises from his body possessing sources of heat production and methods for its elimination, together with a heat-regulating apparatus which ensures that the temperature of the body remains constant.

The production of heat is strictly related to nutrition and muscular activity.

Elimination of heat is carried out: through the skin, by means of irradiation and perspiration; through the lungs, by the process of heating up the inspired air and by the evaporation of water exhaled from the pulmonary surface; and through the digestive system, by means of warming drinks and food which have been consumed. Of these three methods of elimination of heat, the most important is without doubt that of the skin, which by itself eliminates 90 per cent. of the heat produced.
The heat-regulating apparatus is formed by the nervous system and chiefly the vaso-motor nervous system, which causes dilatation or constriction of the capillary vessels, ensuring, in the first case, the loss, and, in the second, the maintenance of heat. This last-mentioned mechanism explains why not only heat and cold but also sudden variations of temperature can cause disease.

Thus, when the surrounding temperature, whether hot or cold, is not uniform, but varies frequently and greatly, the cutaneous vessels, as a result of alternative constrictions and dilatations, undergo changes in their structure, and early arteriosclerosis results. The artery which is the most sensitive is the aorta, which in the process of sclerosing becomes uniformly thickened and elongated, occasioning subjective conditions especially associated with aortic sclerosis.

**INJURIES CAUSED BY HEAT**

Hot air causes two striking phenomena: vaso-motor paralysis and stimulation of the sweat centres, phenomena which are independent one of the other, the first being controlled by the vaso-motor nerves and the second by the excretory nerves of the sudoriparous glands.

In a state of rest, droplets of sweat are not usually formed on the skin under 33° C.; perspiration is carried on imperceptibly. When the external temperature exceeds 33°, perspiration becomes evident and takes the form of sweating which increases with the rise of temperature. As long as the secretion of sweat is moderate, the secreted water evaporates on the surface of the skin, which remains dry (perspiration insensibils); but, when the secretion increases, or, if evaporation is prevented because the surrounding conditions present a high degree of humidity, then the sweat appears on the surface of the skin in the form of little drops, which become united to form larger drops and run down on account of their weight along the skin or are absorbed by the clothing (perspiration sensibils).

Dilatation of the vessels with cutaneous perspiration tends to cool the body, either by increasing the irradiation of the heat, or by increasing the evaporation of the sweat.

If the surroundings are not only warm, but in addition dry, irradiation of heat and evaporation are facilitated and the body is relieved. But when the heat is at the same time moist, phenomena occur to which it is necessary to refer in further detail.

Hot dry air gives rise, by copious sweating, to a considerable loss of materials, especially of water, by the cutaneous path.

Extensive elimination of water through the skin reduces the volume of the blood, by the withdrawal of fluid from the blood and tissues, and, especially, from the subcutaneous cellular tissue, which causes a wrinkled skin. For want of water, intracellular fermentations are attenuated and the anabolic and katabolic functions of intermediary exchanges are altered, with harm to the general condition and loss of vitality.

The blood becomes thickened, and as its viscosity increases it offers an increased resistance to the cardiac systole. The left ventricle dilates and becomes hypertrophied; but, soon after, the myocardium, in consequence of insufficient nutrition, undergoes degeneration which leads to defects in compensation; the condition manifests itself by fatigue, distress, malaise, increased frequency of the pulse and respiration, lowering of the arterial pressure, a feeling of constriction in the epigastric region and oedema at the ankles.

The figured elements of the blood undergo degeneration as a reaction to high temperature. An acceleration in the haemoglobin changes can be observed, and, as the red corpuscles are not regenerated with sufficient quickness, a slight anaemia is set up. The phagocyctic power of the white corpuscles is weakened, which leads to the body being liable to constant infections.

The elimination of fluids through the skin does not sweep away to the necessary degree such products of intermediary exchange as urea, nitrogen and salts, which in consequence accumulate in the body. Thus is produced not only a relative increase of these products, in consequence of diminution in the watery volume, but also an absolute increase which is not compensated by the action of the kidneys. This latter, for its part, is disturbed by reason of the strong concentration of the products in question, which leads to lesions of the renal tubules, the cells of which undergo degenerative processes and prepare the way for nephrosis. All of which leads to auto-intoxication of the body with a diminution of the alkaline reserve, whence arises general malaise, a dulling of the sensory organs, headache, precipitation of the salts in the tissues, with vague and scattered pains, and
oliguria, with thick urine and painful micturition.

The explanation of the dyspnoea which is observed is to be found not only in cardiac insufficiency, but also in excitability of the respiratory centre; thus the body tends, by increased ventilation, to favour the loss of heat. Notwithstanding, a reduction in the volume of blood is produced, an urgent need to take in large quantities of fluid is felt. If this sensation of thirst is satisfied, several evils are reduced, but others remain.

The consumption of large quantities of fluids and their rapid elimination causes sudden disturbances of the arterial pressure which acts on the structure of the vascular tissue and leads to arteriosclerosis. The continual flow of large quantities of water through the system dilutes the juices of the body and the secretions of the glands of organs, leading to a slowing of fermentative actions; the glands of the stomach and the intracellular ferments are seriously affected; hence dyspeptic symptoms follow with poor assimilation of nourishment, and, in consequence, bodily wasting.

If the surroundings are not only warm, but also humid, other pathological phenomena occur of a different kind from those enumerated above. The warm-humid surroundings prevent the evaporation of sweat from the surface of the body and of moisture exhaled from the pulmonary surface; it presents an obstacle to the conduction of heat from the body to the surrounding air, and in consequence it interferes with the two means of loss of heat by way of the skin and the lungs, i.e. irradiation and evaporation.

Under these conditions, overheating of the body may occur and give rise to the morbid phenomena which are characteristic of heat stroke.

Heat stroke, in its mildest forms, is characterised by fatigue, malaise, a sensation of internal heat, burning thirst, a desire for acidulated drinks, dryness of the tongue, anorexia and headache. The skin is dry; sometimes there is fever, a headache. As a rule the whole of the symptoms disappear in between twenty-four and forty-eight hours after a refreshing sleep. But the symptoms may become so aggravated as to produce painful precordial oppression, with dyspnoea, cloudiness of the vision, tinnitus in the ears, vertigo, a tendency to sleep, delirium, and small and frequent pulse. The body may recover from this condition; but death may also occur after a few hours.

A very serious form of heat stroke has been described: the cardiac or syncopal form. The victim falls suddenly to the ground, with a small frequent pulse, and suddenly passes into coma, from which he does not recover. The skin is dry, the face congested and the temperature raised. The coma may be interrupted by convulsions. An asphyxial form is very similar to this cardiac, as a reduction in the volume of blood is produced, an urgent need to take in large quantities of fluid is felt. If this sensation of thirst is satisfied, several evils are reduced, but others remain.

Low temperatures may cause local and general damage.

Local troubles are represented by frost-bites, which will not be referred to here (see article "Skin (Diseases of)", section on Effects of Heat and Cold).

The general damage caused by cold, and, especially, by damp cold, is represented by what are called chills and by diseases due to chills.

In chilling of the body, the same means for controlling the body heat are in action, but with diminution in their function; the ones most often brought into play are the paths of elimination, of which the cutaneous path is the most frequent. The nervous system endeavours to prevent chilling by causing a cutaneous vaso-constriction. In this case the peripheral circulation is reduced to its lowest degree, and the blood flows towards the interior, causing congestion of the viscera. In this way, due to the effect of cold on the skin, cerebral and pulmonary congestions may be produced. But, if the cutaneous vaso-constriction does not occur, or, even if it does, and the loss of heat be great, there may be chilling.

Several forms of chilling are recognised: simple chilling and sudden collapse from cold. The first is characterised by pallor of the skin and constriction of the capillaries. The blood flows towards the deep organs. The body concentrates all its forces to oppose the loss of heat. Shivering and trembling occur, wherein the muscular system reacts with fibrillary contractions intended to light up the body combustion. Reaction may occur at this period, but, if the effects of cold progress, then follows what is a sudden attack by cold.

Sudden attack by cold or cold apoplexy is due to the effect of intense cold. Fatigue, privations, malaise, and immobility favour its occurrence. Cold apoplexy begins when symptoms appear which result from exhaustion.
and paralysis of the different systems. It is characterised by a sensation of fatigue, debility, by painful sensations in the limbs, the head and chest; by lowering of the general temperature, and rigidity and freezing of the extremities. Breathing, at first frequent, becomes slow and deep; the pulse, which was frequent, becomes slow and thready. Stimulation of the central nervous system lessens; the individual feels an urgent desire to sleep, and finally, overcome by the cold, falls into an irresistible sleep, which is the prelude of approaching death.

The anatomical changes consist in hyperaemia of the brain and the internal organs, especially of the heart, and in pleural and pulmonary haemorrhages.

Treatment consists in gentle centripetal massage with vaseline, and in gradual and slow re-warming of the body. This objective can be easily attained by putting the victim into a bath at the temperature of the room, and gradually warming the water up to 30°C., during two to three hours. As soon as the peripheral circulation responds, recourse may be had to injections of cardiac stimulants, and, if necessary, to artificial respiration.

Diseases from chilling include a series of morbid processes of different etiology, such as: inflammations of the air passages, including rhinitis, angina, bronchitis and pneumonia; inflammations of certain serous membranes, including pleurisy and arthritis; inflammation of the muscles, including rheumatism and myositis; of the nerves, comprising the neurites; and of the kidneys, e.g. glomerulo-nephritis.

Bassi in 1931 called attention to the frequency of renal lesions among persons employed in occupations where the temperature is low.

It has been shown that chilling encourages the onset and development of infection by diplococci, by viridans streptococci, and in general the development and evolution of infections, through a reduction of the defensive powers of the body owing to a diminution in the number of leucocytes, with attenuation in their phagocytic activity resulting in smaller production of antitoxins, bacteriolysins, agglutinins and opsonins.

As regards pneumonia a frigore, Galeotti and his pupils hold that there is a correlation between cutaneous vaso-motor phenomena and pulmonary, in that a pulmonary vaso-constriction appears to correspond to a cutaneous vaso-constriction. This fortieth sets up changes in cellular metabolism and in the morphological constitution of the tissues; whence resistance to bacterial invasion is diminished or even phagocytosis is slowed down with retardation in diapedesis.

Pulmonary vaso-constriction is followed by a paralytic dilatation of the vessels, leading to passive hyperaemia. The interstitial transudate which thus arises is a very favourable culture medium for infectious germs.

Some lesions caused by cold have been explained by action at a distance, such as may be instigated by a thorough chilling. Thus Rossbach has shown that the application of ice to the abdomen of a cat is immediately followed by vascular cramp of the trachea; followed after a few minutes by hyperaemia with transudation of fluid which favours the inoculation of germs. In this way is explained the origin of some cases of tracheitis, rhinitis, tophilitis and glomerulo-nephritis, due to cold. In the case of the last mentioned, the cutaneous vaso-constriction is accompanied by constriction of the afferent vessels of the glomeruli, with, in consequence, ischaemia and gangrene of the renal parenchyma, anuria and glomerulo-nephritis.

All that has been stated emphasises the important part played by cold in the genesis of certain morbid conditions.

Whilst heat, either dry or humid, and cold are capable of producing functional changes and true pathological states, it is easily understood that they can render work difficult and even arrest it. In order to weaken the effect of these physical agents, recourse may be had to certain correcting measures.

In the case of heat, suitable ventilation is useful; movement of air without doubt brings a certain relief, which is greater if the movement introduces cooler air into the atmosphere. It is, however, important for the cooling of the air to take place in such a way that the workers are not inconvenienced by draughts. If that should occur, it may cause ill-effects greater than those caused by the heat.

It should, in consequence, be recommended that passing from hot surroundings to cold surroundings should not be done suddenly; in such cases, what are called passage rooms may be recommended, in which the workman can become accustomed gradually to changes of temperature.

In order to prevent the effects of cold, good food is a first necessity: it should include, in a large measure, the foods containing energy or calories,
such as fats and carbohydrates; in this way the production of heat is encouraged. It is also necessary that a man should gradually become accustomed to low temperatures; the body can thus adapt itself, when it feels the ill-effects less. The wearing of clothes which are bad conductors of heat, made of wool, for example, should also be advised. Wherever it is possible, efforts should be made to heat the workrooms; always bearing in mind that the temperature should not descend below 10°C. for work which requires active movements and below 14°C. for sedentary work.

**LEGISLATION**

For the legal measures concerning the temperature of workplaces, see article "Industrial Hygiene (Workshops)". In addition, in France, the Decree of 28 September 1913, dealing with special measures controlling booths outside shops and stores, lays down that in case of cold sufficient means of warming must be arranged for the employees inside the premises. The stables must be provided with pent-roofs or other means for protecting the employees who are working there against inclement weather. A Decree of 21 June 1913 prohibits the employment of young persons and of young girls under sixteen years; boys of from fourteen to eighteen years and girls of from sixteen to eighteen years can only be employed six hours a day with breaks; young persons under eighteen years and women of any age may be employed only up to 8 o'clock in the evening. When the temperature is below 0°C. the employment of young persons and women of any age is forbidden.

As regards compensation for certain ill effects caused by heat and cold, see article "Occupational Diseases: Definition and Compensation".

**Prof. L. Pretti**

(Parma).

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**Tetanus**


Tetanus is an acute infectious disease caused by the anaerobic bacillus, the *Clostridium tetani*, which has the property of producing toxins having an elective action on the nervous centres and giving rise to muscular contractions which form the symptoms of the disease.

In most cases tetanus is a complication of wounds, whence the expression "traumatic tetanus".

The *Clostridium tetani* bacillus is a rod-shaped, anaerobic bacillus forming the tetanus bacillus. The *Clostridium tetani* bacillus takes the form of a very slender, mobile rod having in the majority of cases at one of its extremities a bright sphere in which spore reactions occur; this is the tetanus spore. This conformation gives to the bacillus the appearance of a drumstick. The unsporulated bacillus is of feeble resistance. It is the spore which constitutes the propagation agent in the tetanus. The anaerobic bacillus is pathogenic for man and the domestic animals, especially the horse. It becomes lodged at the point of contagion, but it acts at a distant point therefrom by the intermediary of a very active toxin which becomes fixed in the nervous centres, giving rise to violent stimulation of the motor cells, whence occur permanent muscular contractions, with redoubled paroxysms which are characteristic of the tetanus attack.

This symptom complex can only develop when a certain amount of the toxin has been produced in the system. It is necessary for this that the bacillus becomes lodged in the body and multiplies. This moreover takes place, in general, to a limited extent.

This is what occurs in the case of wounds infected simultaneously by *anaerobic* germs (for instance, *staphylococci*) which, by consuming oxygen, create around the tetanus germs, which have arrived in the wounds in the form of spores, a sufficiently anaerobic medium. Wounds contused by tearing or crushing, with consequent attrition of the tissues, mortification or deep-seated lacerated wounds, open fractures in the presence of foreign bodies, particularly those of a porous nature which contribute to creating anaerobic conditions, prevent phagocytosis and increase the likelihood of tetanus infection.

The *toxin* possesses the general characteristic of toxins that is to say, when inoculated into animals with requisite proportions and by repeated doses in order to avoid killing the animal, but with the intention, on the other hand, of conferring on it progressive immunity, it causes to appear in the blood an anti-toxin capable of neutralising the toxin even in *vitro* and in *vivo*. It is this anti-toxin, such as it is found in the blood serum of immunised animals, which is largely employed in therapeutic treatment, and with excellent results in the serotherapeutic treatment of tetanus.

The tetanus bacillus in the form of highly resistant spores exists outside,
especially in the cultivated ground of
manured or rather filthy fields and
gardens in the country; likewise in the
dust and mud of roads or routes, and
in the mud of rivers and ponds, etc.
Finally, spores are everywhere through animal excre-
ment, and in particular that of the her-
ivorous animals. The spore introduced
into the intestine of these animals
would appear to find favourable con-
ditions for propagation. Herbivorous
animals therefore constitute agents of
propagation and dissemination of these
germs, whilst the ground only serves
as a depot for their conservation.
This explains the very high tetanus-
infesting capacity of manure heaps
and manured ground, as well as the
quite particular incidence of tetanus
amongst peasants, stable-boys, more
especially when they are in the habit
of walking barefoot, and in general
amongst those workers likely to receive
wounds from tools soiled with dust or
earth from the manure heaps.
In addition to agricultural workers
and peasants, tetanus of occupational
origin has been reported amongst
workers in slaughter houses, knack-
ers' yards, and amongst workers en-
aged in tinning food products, sorters
of bones, horns and hoofs (Koberl), rope-
makers (Oliver), laundresses (Oliver: 2
cases), paper, rag and metal sorters
(in a depot for factory refuse: Hay-
hurst); in jute manufacture (Legge),
and amongst Hungarian pottery work-
ers. On the contrary, no case of
tetanus occurring in mines is known,
despite the fact that horses and mules
are used in these.
Besides cases of occupational tetanus,
mention should be made of tetanus
occurring amongst the wounded during
warfare. The danger from tetanus
is well known in the case of war
wounds, and certain battlefields would
appear to have been particularly
favourable to the outbreak of extensive
epidemics. Tetanus may again occur
subsequent to delivery or miscarriage
through infection of the umbilical
wound (tetanus neo-natorum), or as a
consequence of surgical treatment (cat-
gut, haemostatic gelatine, etc.),
or serum injections. In civilised coun-
tries, however, these forms of tetanus
are of increasingly rare occurrence.
The negro races, Hindus and Malays
appear to be particularly sensitive to
tetanus. There exists in general a
fairly marked predisposition amongst
the inhabitants of hot countries (pri-
mitive habits, ignorance and rudimen-
tary ideas of hygiene), who are
in the habit of walking barefoot and
live in damp huts made of mud. etc.
The incubation period for tetanus in
man varies in accordance with circum-
stances from two to fourteen days. It
may even on occasion be longer for
retarded tetanus; the cases in question
are relatively uncommonly immu-
ised subjects in whom the outbreak
of the disease is provoked by some
special cause (chill, traumatism, etc.)
which diminishes the organic resistance
and enables the germs to get the upper
hand, to multiply and thereafter cause
infection. Cases of this type were
formerly designated "rheumatic tetan-
us" in the absence of satisfactory
explanations of the mechanism of in-
fec tion.
In certain cases, symptoms of in-
vasion of the system and of the disease
itself are preceded by premonitory
local or general phenomena. Tetanus
is characterised by permanent contrac-
tions which affect particularly the
muscles of the jaw (hence trismus), the
muscles of the back of the neck and of
the back (hence opisthotonos). These
contractions finally spread to the
muscles of the face (tetanic mask,
sardonic grin) and at times to those of
the tongue, pharynx, larynx, the trunk
and the vertebral column. In certain
cases the patient only touches his bed
with his head and sacrum, the back
being bent in the form of an arc. The
contractions which
affect the muscles of the hand and the forearm,
include the diaphragm.
The duration of the illness
may vary from some hours to some
weeks. Death may be due to a spasm
of the glottis, to sudden syncope,
paralysis of the heart, or permanent
contraction of the diaphragm.
The patient may however recover, even in
very serious cases. Where the disease
runs a long course, it may often be
followed by respiratory trouble (bron-
chitis, broncho-pneumonia or pneumo-
nia ab ingestis, etc.).
Clinical diagnosis should be con-
firmed by bacteriological research: re-
search for tetanic bacillus in the secre-
tions from the initial wound, and
when the germ has passed the point
of inoculation in the system, research
should be effected with a view to
finding it in the blood or in the spinal fluid
(cultures, inoculation of animals, de-
monstration of the tetanic toxin in the
blood or in the spinal fluid of the
patient).
Prophylactic measures comprise adequate treatment of all wounds, even the slightest, and the preventive injection of anti-tetanus serum as soon as there exists any suspicion of contamination of the wound by tetanus-infected material. Serum injected opportune is most effective and Ottolenghi is of the opinion that the use of this prophylactic agent is not sufficiently recommended in all cases of suspected wounds. Once the tetanus outbreak has occurred, the effect of the serum is much less certain and the probability of recovery much more doubtful.

Tetanus is subject to compulsory notification in the Netherlands when it affects farm workers, butchers, rag sorters, workers engaged in demolition work, those engaged in the manufacture of animal black, paper and cardboard, as well as cobblers, navvies and gardeners. Victims are entitled to compulsory compensation in Brazil (farm workers), in Chile, Illinois, Mexico (grooms, butchers, stable-boys and workers looking after animals), in Queensland (hospital staff) and the U.S.S.R. (workers engaged in cultivation, forestry and digging foundations).

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### Tetrachloretane
(or Acetylene Tetrachloride)

French: *Ethane tétrachloré*, or *Tétrachloréthane*, or *Tétrachloruré d'éthane*, or *d'acétylène* — German: *Tetrachloräthan*. — Italian and Spanish: *Tetrachloretano*.

#### CHEMISTRY

Tetrachloretane is a halogen derivative of the homologues of methane, of which the formula is $\text{CHCl}_2$, $\text{CHCl}_3$; it has a boiling point (without decomposing) of between 142° and 147° C. and a specific gravity of 1.58. It is a yellowish liquid, with a smell recalling that of chloroform, non-inflammable, soluble with difficulty in water, slightly volatile, and non-explosive. It is a powerful solvent of organic matters in general and of acetate of cellulose in particular. It is acid resistant. It can be mixed with nitric acid even at a high temperature and under strong pressure.

#### Manufacture

Tetrachloretane was manufactured for the first time in large quantities with a view to technical use in 1903 and placed on the market in 1907 (in Austria) as a solvent of fats and resins. It is obtained by passing acetylene over antimony pentachloride. The acetylene is absorbed and a special compound is formed, into which chlorine is introduced. Each molecule of acetylene fixes four atoms of chlorine and the tetrachloride is formed, and then, again, the pentachloride of antimony. Nowadays it is preferable to combine chlorine and acetylene directly, using antimony chloride as a catalyst. Many processes of manufacture are in use which allow the two gases to combine without risk of explosion.

#### Uses

In the chemical industry for the manufacture of other chlorine derivatives of carbon; boiled with lime and water tetrachloretane loses HCl and yields trichloretylene $\text{CCl}_3$, $\text{CHCl}_3$; on treating tetrachloretane in suspension in water with powdered zinc, a rise of temperature occurs and pure dichloretylene $\text{CHCl}_2=\text{CHCl}$ is distilled; it is used for the extraction of fats or of certain alkaloids (quinine, cocaine), as a solvent of sulphur, acetate of cellulose, or rubber, nitrocellulose or viscose (artificial silk), etc.

It is used in the colour industries, in varnishes and lacquers. During the war it was used as a solvent for cellulose acetate to cover aeroplane wings ("doping"). These varnishes were made up of a solution of acetate of cellulose, tetrachloretane, acetone, benzene, methyl alcohol and amyl acetate. The proportion of tetrachloretane in some solutions reached 60 per cent., in others 35-35. Aeroplane wings vary from 6 to 10 m. in length.

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1 The following is the list of chlorine derivatives of carbon which can be utilised as solvents in industry; stated in order of their relative toxicity as compared with carbon tetrachloride, according to Lehmann, 1911:

<table>
<thead>
<tr>
<th>Formula</th>
<th>Boiling point</th>
<th>Density</th>
<th>Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{C Cl}_4$</td>
<td>76</td>
<td>1.59</td>
<td>1.0</td>
</tr>
<tr>
<td>$\text{C}_2\text{H}_4\text{Cl}_4$</td>
<td>121</td>
<td>1.61</td>
<td>1.8</td>
</tr>
<tr>
<td>$\text{C}_2\text{H}_5\text{Cl}_3$</td>
<td>88</td>
<td>1.46</td>
<td>1.9</td>
</tr>
<tr>
<td>$\text{C}_2\text{H}_5\text{Cl}_4$</td>
<td>55</td>
<td>1.28</td>
<td>2.3</td>
</tr>
<tr>
<td>$\text{C}_2\text{H}_6\text{Cl}_3$</td>
<td>61</td>
<td>1.49</td>
<td>2.7</td>
</tr>
<tr>
<td>$\text{C}_2\text{H}_6\text{Cl}_4$</td>
<td>159</td>
<td>1.67</td>
<td>8.1</td>
</tr>
<tr>
<td>$\text{C}_2\text{H}_7\text{Cl}_4$</td>
<td>147</td>
<td>1.60</td>
<td>11.8</td>
</tr>
</tbody>
</table>

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and from 1.80 to 3 m. in width, so that the evaporating surface was great. Four to six coats of varnish were applied, and each was allowed to dry before applying the next. Usually two workmen were employed simultaneously, opposite one another.

Tetrachlorethane is still used in the manufacture of enamels, for cleaning pictures, inking rollers for lithographic plates, for the manufacture of films, artificial pearls (see that article), gas masks (as a solvent of acetate of cellulose used to join the transparent sheets of so-called mica, but really acetate of cellulose and in the manufacture of certain "cements" (e.g. for shoes). As it is not explosive, tetrachlorethane is often used instead of carbon bi-suiphide, petrol and benzene. See also article "Pearls (Artificial)."

TOXICITY

For some time it was thought that this substance and solutions containing it were not toxic, but produced temporary narcotic effects like those of chloroform. While, however, the latter had only rarely given rise to symptoms of jaundice, tetrachlorethane induced several such cases. Laboratory experiments (on white rats) served to reproduce the same clinical picture as was found in man (jaundice, fatty degeneration of the liver, etc.). Poisoning is brought about by inhalation of the vapour, and the danger is by so much the greater as its action is slow and its smell pleasant. The worker, therefore, is not sufficiently on his guard. The vapour of this substance is four times as toxic as that of chloroform and the most toxic of the series.

According to experience in England, the organs found most affected are the kidneys and liver. The lesions resemble those set up by T.N.T. without the changes in the blood, such as are set up by nitro-derivatives of benzene and its homologues. The toxic jaundice is of hemo-hepatic character, an obstructive jaundice due to inflammation of the intrahepatic biliary canaliculi as a consequence of direct action of the poison on the hepatic cell. It resembles delayed chloroform poisoning in causing jaundice, and fatty degeneration of the liver, the latter being greatly reduced in size. The kidneys and heart are markedly affected. In severe cases, fatty degeneration affects the muscles also.

Individual susceptibility is very variable. Workers who have had slight attacks and return to work are specially susceptible. A second attack often develops rapidly, terminating in death.

Lehmann gives the following figures as the dose of tetrachlorethane necessary for narcotising cats (these are figures per litre of air): 30-60 mgr. during 5-10 minutes narcosis; about 10 mgr. during 30-60 minutes, narcosis with convulsions; 5 mgr. during 30-60 minutes, no effect.

STATISTICS

France.—During the war, at least 12 fatal cases came to light in the aeroplane and gas mask industry. Probably the number that really occurred was much larger. Recently, cases have been reported in the making of artificial pearls (see that article).

Since 1915, the French Government has prohibited the use of varnishes and dopes containing tetrachlorethane either on account of the symptoms produced or of the technical disadvantages of the substance.

Germany.—In 1913, 10 severe cases of jaundice were reported in Prussia from use of Aviatol and one affecting a saddler who used solution of acetate of cellulose in tetrachlorethane as a cement. In 1914, at Tettow, 15 cases occurred of which several were severe and two fatal; the dope contained 40-60 per cent. (Aviatol, Quitiners, Emaillite). In the early part of 1914, in spite of close regulation, 10 cases with one death occurred in Prussia and from that time its use was prohibited. In Bavaria, similarly, 9 cases with one death were reported from the same cause.

Great Britain.—In 1914, 25 cases, of which 4 were fatal, came to light. According to the report of the Medical Inspector of Factories, up to September 1916, 70 cases of toxic jaundice had been reported, of which 12 proved fatal, besides many slighter cases of illness. In 1917, use of tetrachlorethane was replaced by a solution containing ketones, and benzene, after which only a few cases of jaundice were reported.

Netherlands.—Poisoning was not reported; notwithstanding, the use of Emaillite (generally of German and sometimes of
English origin) caused cases of poisoning in 1915. Analysis showed that the former contained 5-10 per cent. of carbohydrate and tetrachlorethane, and the latter 50-60 per cent. and chloroform as well. Use of the material was prohibited.

United States. — Enquiries by Hamilton in 13 aeroplane factories (in 1917-1918) did not bring to light evidence of occurrence of severe cases of poisoning. According to Lister Roos and R. Bell, however, of 52 persons engaged in doping aeroplane wings, 35 suffered from slight trouble of whom 2 had jaundice and 26 nervous and gastro-intestinal symptoms.

Symptoms

In practice, the clinical picture varies a good deal from one individual to another. Early signs are abnormal fatigue, sweating, loss of appetite, general malaise, somnolence, vertigo, nausea, abdominal pains, nasty taste in the mouth, constipation.

After some days or weeks, jaundice appears with headache and vomiting. The jaundice is more or less marked (skin, conjunctivae) with or without toxaemia. In severe cases, insomnia, stupor, delirium, convulsions and coma are prominent. Petechiae are not uncommon as well as haematemesis and anuria.

Among workers in artificial pearl factories (see that article), peripheral nervous symptoms have been reported.

Blood. — According to Minot and Smith of Boston (1922), the blood may show, even in the absence of clinical symptoms, characteristic changes (large mononuclears up to 12 and even 40 per cent. and more in cases of definite poisoning; increase in the platelets; slight diminution in the number of the red blood corpuscles).

Manipulation of the varnishes, dopes, etc., containing tetrachlorethane has set up eczema, especially of the fingers.

Diagnosis

This should be effected as early as possible, so as to remove the worker from the serious consequences of the poisoning. The history of the case is of the greatest importance.

Detection

The smell in a proportion of as little as 1 mgr. per litre is perceptible (like that of chloroform but more pungent) and such air may be held to be suspicious. To demonstrate the substance, allow air to be bubbled through an alcoholic solution of potash and test for the chlorine set free after a time. Examination of the viscera is work for the toxicologist.

Hygiene

As the vapour is heavy (six times that of air) it is of first importance that the system of ventilation should be by downward extraction. If localised ventilation is impracticable, the fumes should be removed by fans placed at the level of the floor. If it is not well planned, the condition may be made worse. During the war, before the use of tetrachlorethane for the doping of aeroplanes was abolished in Great Britain, 20 to 30 changes of the air of the room were required per hour, which did much to lessen incidence of poisoning. Rooms should be ventilated in such a way as to prevent perception of the smell, or permit not more than 0.001 grm. per litre (Kohn Abrest). Vapour even of mixtures containing tetrachlorethane should be prevented from escaping into the room, as serious illness may be caused to the workpeople thereby. Doping should be done in rooms set apart for the purpose, and equipped with the necessary means for preventing inhalation of the vapour, etc. A less solvent toxic should be substituted for tetrachlorethane in all "cements" or mastics.

All persons exposed to the fumes should be examined before employment and periodically afterwards. Individuals who are subject to gastric trouble (especially of the liver) should be rigorously excluded and all those showing the earliest symptoms transferred to other employment.

Legislation

A special Order concerning the use of tetrachlorethane was promulgated in Prussia on 30 April 1920. Notification of toxic jaundice was made compulsory in Great Britain in 1915 and also in the Netherlands and in the States of Minnesota and New York. Poisoning by tetrachlorethane is compensated in France, Great Britain, Switzerland, United States (Ohio) and Venezuela.

Bibliography


Feois M., in Bull. Acad. de Médecine, 1922, No. 28, and Journ. de Méd. de Bordeaux, 25 July 1924.
Tetra-Ethyl Lead


TECHNICAL DATA

Tetra-ethyl lead (Pb(C₂H₅)₄) is a colourless, clear liquid, specific gravity 1.62 at 15° C, boiling at 200° C, oily, with a sweetish odour, volatile at ordinary temperature, insoluble in hot or cold water, soluble in alcohol and acetone, miscible with fats and oils. When exposed to sunlight or evaporation it decomposes and one of the products of decomposition is triethyl lead. This is often found in crude tetra-ethyl lead or in old containers (Kehoe).

The product in question, though known since 1854, was not for a long time applied industrially. Recently it has found technical application, being used to eliminate the "knock" or detonation in internal-combustion engines, and it was its extreme toxicity, as noted in the course of its manufacture for this purpose, which drew the attention of scientists to this product.

Modern technical tendency has been towards the manufacture of smaller and less expensive motors, but having a higher compression rate with a view to increasing their efficiency. Commercial petrol as regards compression hardly permits of exceeding about 4.5 to 5 kg. per sq. cm.; above this limit the combustion is explosive and the motor knocks. Therefore, the addition of organo-metallic compounds soluble in the petrol, which would permit of a distinct increase above this limit, was proposed. The products which were suggested for this purpose are known under the name of "anti-detonants". It is claimed that they possess the property of retarding detonation and attenuating the over-violent shock to the walls of the cylinders and the piston head.

Generally, phenylated or methylated compounds, etc., as well as compounds of selenium, tellurium, arsenic, antimony, tin, and lead possess the properties in question. Yet all the products suggested as anti-detonants have co-efficients inferior to tetra-ethyl lead which, according to the experiments of Midgley, exerts a marked action in suppressing detonation in the proportion of one in 200,000 molecules of a combustible mixture of lamp petrol with air. The most effective products besides tetra-ethyl lead are diphenyl lead, dimethyl lead and diethyl lead, diiodised lead and dichlorated lead (see below).

The manufacture of tetra-ethyl lead involves difficult operations from the point of view of technical chemistry. The principle followed consists in making an alloy of lead sodium react on ethyl bromide in presence of a reducing agent and a catalyst. The product obtained is distilled and condensed. The process may be effected starting with a magnesium ethyl iodide on which lead chloride is made to react.

As reducing agent may be used silicon or ferrosilicon in presence of water or soda lye, etc. As catalyst may be utilised those generally used in the Gignard reaction such as: the ethers and primary, secondary and tertiary amines, aniline diethylarsine, toluidine, diphenyl amine, pyridine (the most frequently used), carbazol, etc.

Tetra-ethyl lead is placed on the market in the form of an "ethyl fluid", that is to say, a mixture of 60 to 75 per cent. of lead tetra with a solvent (at first carbon tetra-chloride was used, but now there is used chiefly an alkyl-halogen, mainly trichloroethylene or ethyl-dibromide, which are likewise poisonous). The solvents proposed for use in anti-detonants are pure alcohol, pure ether, benzene, xylene, etc., and they are used with the intention of facilitating the elimination of the lead after combustion. The ethyl fluid is added to the petrol in the proportion of 1 to 1,000 or 1,400.

The role of the tetra is to decompose, leaving tiny drops of metallic lead which are deposited in the accumulations of dust and on the salient parts of the motor, diminishing their catalytic capacity. According to other experts it acts by diminishing the degree of ionisation of the mixture. The tetra is held to constitute in some way a negative catalyst.

TOXICITY

The effect on the skin is corrosive and necrotic only after prolonged contact, as determined by experiments on animals.

The systemic effect closely resembles the action of triethyl and trimethyl lead as determined by Harnack in 1878 and confirmed by Mason in 1921. The most important features shown in these experiments are: a stimulating action on the central nervous system, mainly the medulla and medulla oblongata, a marked stimulation of the central motor nerve mechanism, evidenced by trembling, twitching, and, finally, con-
vulsions, but without loss of consciousness; an extreme fall of blood pressure, apparently central in origin, for it fails in pithed animals; changes in the respiration, which at first is stopped, and then accelerated and deepened; slowing of the pulse, and increased peristalsis with colic and diarrhoea.

Eldridge, of the United States Chemical Warfare Service, tested tetra-ethyl lead on animals. His findings are as follows: Experiments on six dogs showed that application of tetra-ethyl lead to the shaved skin of the abdomen resulted in a direct action on the intestinal tract, characterised by acute lead colic, followed by diarrhoea, the abdomen tense and painful to pressure; then depression, difficulty in getting up on the legs, tremors, coma, convulsions; and death. The lethal point for dogs by skin absorption was found to be 0.3 c.c. per kilogram of body weight. Death followed in four dogs after from 24 to 180 hours, two recovering. In 11 guinea-pigs the lethal amount was determined to be 0.6 c.c. per kilogram of weight, and death occurred in from 12 to 16 hours. Three of this group recovered. The symptoms were similar to those in the dogs.

Inhalation experiments were made on mice, five animals being used for each of ten concentrations of tetra-ethyl lead. The exposure lasted ten minutes, and during this time the mice showed activity, followed, after removal from the test chamber, by marked excitement, then depression, collapse, trembling, convulsions and death. The lethal dose averaged 5.11 mg. per litre of air.

To determine possible cumulative effects, a 4.08 kg. dog was chosen, and applications of 0.1 c.c. were made to his skin once a day. After the 12th application the dog became depressed and nervous, and increasingly so until the 18th, when he became unsteady on his feet and trembled. He died 40 minutes after the 21st application. The cumulative action was also tested on mice, by inhalation experiments, exposing ten of them to 0.05 mg. per litre of air for ten minutes a day. Five died, on the 14th to the 20th days.

Necropsies on the dogs dying with acute poisoning showed an acute inflammation of the small and large intestines, with numerous ulcers from 1 to 1.5 cm. in diameter, clean and punched out, with a smooth base. These were chiefly in the region of Peyer's patches, which were swollen and protruding, and with a similar ulcer near the pyloric end of the stomach; one had no lesions in the intestinal tract at all. There was no change in the heart, lungs, liver or spleen but a mild congestion in all zones of the kidney. Analyses were made of excretions, organs and bones of dogs and guinea-pigs, and lead was found in both urine and faeces, in skeleton, intestines, liver and lungs, by far the largest amounts being in the skeleton. Eldridge comments as follows:

"We are dealing with a highly lipoid-soluble lead compound, which is capable of skin penetration and which, furthermore, is comparatively stable. It is probably the only compound which absorbs through the skin, causes acute lead poisoning."

**SYMPTOMS**

In human beings the effects of mild and of severe poison have been reported by Kehoe, Gilman Thompson, and A. W. Schoenleber. According to Kehoe, the effect of tetra-ethyl lead differs clinically in marked degree from that of the ordinary compounds of lead, with the exception of those rare cases of acute lead encephalopathy, probably because it is more rapidly absorbed than any other compound and is also readily soluble in fats, which leads to its concentration in the central nervous system and in the liver. Poisoning in man takes place through inhalation or through the skin. The following is a description of the symptoms which follow slight and brief exposure: insomnia, anorexia, slight fall in blood pressure, and in temperature, stippled red blood cells and leucocytosis if the exposure is prolonged, though slight. Possibly there may be a lead line.

In cases with longer and severer exposure, the symptoms occur in the following order:

1. Insomnia, one of the earliest and most troublesome symptoms, with restless, excited dreams.
2. Anorexia, nausea and vomiting, especially early in the morning, and a sickening taste which increases aversion to breakfast. An attack of vomiting may be brought on by the odour of tetra-ethyl lead.
3. Vertigo and headache, but seldom severe.
4. Muscular weakness, a later symptom and probably due to loss of sleep and appetite.

The signs are: pallor, which is impressive and out of proportion to the anaemia; subnormal blood pressure, an early and reliable sign, the diastolic pressure being almost always relatively lower; subnormal temperature especially in the early morning, rarely above
97° F.; loss of weight; tremors, coarse and well-defined, with exaggerated reflexes and hyper-irritability of the muscles, which may be continuous and exaggerated by efforts at control; sometimes sudden violent twitchings; increased respiratory rate and decreased pulse rate.

Symptoms which are important in ordinary lead poisoning and not in this form are: gastric and intestinal cramps, constipation and diarrhoea, which are either absent or not severe. The blood findings are negative except in slow absorption when stippling may appear; but is not an early nor an important item in diagnosis. The lead may appear; but is not an early nor an important item in diagnosis. The blood findings are negative except in slow absorption when stippling may appear. The urinary findings are slight except for the presence of lead. There is no albumin even in severe cases. Excretion of lead by the kidneys and faeces is greater than in most cases of lead poisoning and may reach 3.4 mg. in 24 hours.

In May 1924, W. Gilman Thompson and A. W. Schoenlebei reported their observation of the severe and fatal cases which had occurred in the autumn of 1923 in the Standard Oil Company's works in New Jersey, as follows:

The first symptom noticed is a marked fall in blood pressure, sometimes 60 mm. of mercury below normal, an accompanying fall in body temperature, which has been as low as 94.6° F., and a low pulse rate, down to 48 a minute. Then symptoms of profound cerebral involvement appear, persistent insomnia, extraordinary restlessness and talkativeness, and delusions. The gait is like that of a drunken man, but there are no paralyses or convulsions. Finally, after a period of exaggerated movements of all the muscles of the body, with sweating, the patient becomes violently maniacal, shouting, leaping from the bed, smashing furniture, and acting as if in delirium tremens; morphia only accentuates the symptoms. The patient may finally die in exhaustion. In two fatal cases, the body temperature rose to 110° F. just before death occurred. One of these was a young man of fine physique who had been at work only five weeks. He is said to have suffered terrible agony.

There is no cyanosis or dyspnoea; there may be vertigo, and the acute outbreak may be preceded by a period of anorexia, vomiting and diarrhoea. Changes in the red blood corpuscles are noted, and the blood of one of the men who died failed entirely to coagulate. It had the colour typical of carbon monoxide haemoglobin. In one case the systolic blood pressure dropped from 190 to 112 mm. of mercury in three and a half hours, a fall commensurate with that following a severe haemorrhage. Convalescence is slow, and may take from six to ten weeks.

From the Pont de Nemours Company's physicians, Eldridge secured a report of the symptoms in 28 cases of tetra-ethyl lead poisoning. The most frequent finding recorded is insomnia (28 times); then follows a markedly lowered blood pressure (20); a sub-normal temperature (19); anorexia, nausea, and hyperacidity of the urine (18); bodily weakness (16); abdominal cramps (12); unaccustomed and annoying dreams (11); vertigo and morning vomiting (11); decided loss of weight and headache (7). Other less frequent findings were a metallic taste in the mouth, tremors, a lead line on the gums (in 4 cases), and itching of the skin. Lead was detected on the skin of 12 men.

Biondi and his collaborators during 1929-1931 studied poisoning by tetra-ethyl lead. Biasi found as a result of animal experiment that the symptoms chiefly affect the central nervous system, the organ most affected being the sight (marked mydriasis, hyperaemia followed by anaemia of the papilla). In the blood no stippled cells were found nor young red cells nor modifications of the leucocytic count. Mene-sini has proved that there is likewise no change in the acid-basic metabolism nor in the calcium content of the blood. It may be stated that, contrary to the other lead compounds, tetra-ethyl exerts no special action on the hemapoietic system.

It is impossible to say just how many cases of acute poisoning occurred between the autumn of 1923 and the early spring of 1925, because a good deal of secrecy was maintained. The deaths numbered 11 or 18. The cases including the mild ones are supposed to have reached over 100.

Diagnosis

The diagnosis, according to Kehoe, must be based on the history of exposure to tetra-ethyl lead, the presence of lead in urine and faeces, and the symptoms outlined above, but the latter are not in
TETRA-ETHYL LEAD

mild cases characteristic of tetra-ethyl lead; they are not to be distinguished from those of tuberculosis, syphilis, chronic myocarditis, or chronic, sub-acute infections with systemic intoxication, except through the history of exposure.

Eldridge found that the best agent for cleansing the skin after splashing was kerosene, followed by tincture of green soap. Animals so treated survived even if 30 minutes elapsed before washing the skin. Prevention depends on the use of fume-proof apparatus and the absence of splashing.

The treatment is the same as for ordinary acute, severe lead poisoning. Kehoe, finding that the urine is always hyper-acid, uses alkalkalisation by sodium bicarbonate or citrate, with magnesium oxide and calcium carbonate, sufficient to make and maintain neutrality of the urine. He warns against opium and chloral hydrate as dangerous for delirium.

ENQUIRIES

Autopsies were made on four cases of acute fatal poisoning, by Charles Norris, Chief Medical Examiner, New York City, and A. O. Gettler, Chief Toxicologist. The cases were young white men who died in acute delirium after varying periods, 12 1/4 hours, 21 hours, 3 days and 10 hours, and 5 days after admission to the hospital. In all there was a yellowish discoloration of the skin and haemorrhagic foci in the bone marrow. Three had haemorrhagic broncho-pneumonia with intense pulmonary engorgement, the lungs resembling those of malignant influenza. In one, the tissues were much desiccated and in another there was yellowish discoloration of the cerebral cortex and chronic leptomeningitis. The striking microscopic features were: intense engorgement with frank haemorrhage in the lungs, in two cases, a general visceral congestion except in the liver, and congestion of the vessels of the brain with red blood cell thrombi. The striking chemical finding was the isolation of a volatile lead compound in the brains of two of the four cases. The amount present at the time of analysis was, in Case 1, 4.25 mg. and, in Case 2, 4.77 mg. Lead in non-volatile form was also found in these brains. These were the two men who had died within the first 24 hours after admission. In the other two, no volatile lead compound was found. The fluids of the tissues had hydrolysed most of the tetra-ethyl lead to a non-volatile lead salt, for no volatile com-

The lead content of the lungs was also somewhat high, pointing to absorption through inhalation. 2.25 mg. to 6.71 mg. The liver contained a large amount, indicating attempt at excretion. 30.53 mg. to 61.47 mg. The kidneys contained from 3.48 mg. to 10.66 mg. All the organs, including the blood, contained lead, pointing to a very recent intake of lead.

Flinn took up the question of danger from splashing or spillage of tetra-ethyl lead, of ethyl gasoline 1-1,000 on the clothing or the skin, and the danger of fumes from spilling in garages. He used rabbits, guinea-pigs, rats, goats, pigeons, and monkeys, exposing them to contact with ethyl gasoline, and to the fumes, and he found that a deposit of lead in the body followed exposure to a 1/1,000 mixture, both by skin absorption and by inhalation, the latter mode of entrance being the more rapid.

The further danger to garage employees and to the public from the use of tetra-ethyl lead in gasoline being retained in the form of sulphate. A quantitative analysis made by the Bureau of Mines investigators of the deposits in the engine head, exhaust pipe, crank case, and drip pan under the exhaust outlet, showed that 95.2 per cent. of the deposit consisted of lead, of which 40.1 per cent. was in the form of chloride or bromide and 55.1 per cent. in the form of sulphate. The bromide is very soluble in water, and so is the chloride, the figures being 8.3 grm. per litre for the former, 9.6 grm. for the latter. No lead compound ordinarily used in industry is nearly so soluble.

The danger to the public and to the workers in garages of chronic lead

1 The word "petrol" has been retained in the parts of this article taken from European sources and the word "gasoline" in the majority of cases based on American data in accordance with the American practice.
poisoning from the fine lead dust in the exhaust gases was emphasised by Zangger, of Zurich, and was prominently exploited by some of the American newspapers. In consequence, the industrialists interested in ethyl-gasoline requested the U.S. Bureau of Mines to undertake experiments which might clear up this subject, and these were begun in December 1923, the results being published just one year later. The experimenters used ordinary motor gasoline, to which was added 3 c.c. of tetra-ethyl lead and 2 c.c. of ethyl dibromide or trichlorethylene, approximately 0.04 and 0.06 per cent., respectively, by volume. The apparatus used was a 1,000 cubic foot air chamber, through which air was driven at the rate of 30,000 cubic feet an hour, making a complete change every two minutes. Twenty-three rabbits, 15 guinea-pigs, 4 pigeons, 8 dogs, and 2 monkeys were exposed for three hours daily to exhaust gases generated by a Delco engine; an equal number of rabbits and guinea-pigs, 3 dogs and 4 pigeons were given six-hour exposures, and about half as many rabbits, guinea-pigs, and pigeons were kept as controls.

Of the animals, about a half of the rabbits, both test and controls, died and about 25 per cent. of the test guinea-pigs, but all deaths were attributed to accident or disease. No loss of weight was noted, no anaemia, no lead lines, no evidence of lead poisoning through symptoms or from analysis of tissues. Very insignificant amounts of lead were found in the carcasses of 7 guinea-pigs, 1 dog and 11 rabbits, examined by Fairhall’s method, the largest quantity being 0.33 mg. per 100 grm. of body weight. Lead was daily given to test animals, and the authors conclude that latent or delayed poisoning is not a possibility under these circumstances since no storage of lead took place.

This report was not accepted as truly convincing, partly because of the small number of animals that actually went through the tests, the mortality of both test and control animals being excessive. The material was also presented in insufficient detail so far as regards a study of the lead dust in the exhaust gases. Therefore, a request was made that the Surgeon-General, Dr. Hugh S. Cumming, should summon a conference for the purpose of deciding what further steps should be taken. Dr. Cumming called together on 20 May 1925, in Washington, D.C., a group consisting of manufacturers, industrial chemists, industrial physicians, hygienists, toxicologists, and specialists in internal medicine. It was agreed that a small body of impartial experts should undertake the enquiry, and the manufacturers voluntarily pledged themselves to suspend the distribution of ethyl gasoline until the report of these experts had been made.

Dr. Cumming appointed the following men as a committee:

W. H. Howell, Johns Hopkins University, Chairman.
D. L. Ebsall, Harvard Medical School.
Reid Hunt, W. S. Leathers, Vanderbilt University.
Julius Stieglitz, University of Chicago.
C. E. A. Winslow, Yale University.

Their report was presented to the Surgeon-General on 17 January 1926, and may be briefly abstracted as follows: The committee felt that while animal experiments had yielded important results, the crucial test must be derived from actual experience in the use of ethyl gasoline under practical conditions of operation. They therefore undertook the examination of five groups of men. Group A was a control group of chauffeurs using gasoline without lead. They had never used leaded gasoline. Group B had for almost two years used ethyl gasoline. Group C served as control for Group D. Both groups were garage workers who either had not used ethyl gasoline at all (Group C) or had worked in garages handling ethyl gasoline for almost two years (Group D). Group E consisted of men employed in two industrial plants where there was known to be serious exposure to lead dust. This group was selected for what might be called a positive control or check in regard to the validity of the clinical and analytical methods used, in the study of the other groups.

Each individual was subjected to a careful clinical examination, an examination of a blood smear was made by a skilled observer, and an examination of the faeces for lead was made by a specially trained chemist. Neither of the two latter knew whether the specimen in question came from a control or from a man supposedly leaded. Special attention was given to three methods which it was hoped would yield data of an objective character. These were, first, the determination of the amount of lead in the faeces, as an index of lead ingestion or absorption; second, the estimation of the number of stippled red cells, which, in the absence of other causes,
might also be considered as an index of lead absorption; third, measurements of the strength of the extensor muscles of the forearm, as an index of lead poisoning. The first two methods yielded results of positive value, but the last was practically negative so far as the present investigation is concerned.

The clinical examinations failed to give any decisive indications of lead poisoning among the chauffeurs or workers in garages in which ethyl gasoline was used as a motor fuel. The median time of potential exposure among these men approximated two years, and this negative result, therefore, holds good only for a period of that duration. It should be added that in Group E, comprising workers in industrial plants in which there was a known and serious exposure to lead dust, definite clinical symptoms of lead poisoning were revealed, although these workers had been exposed for shorter periods of time.

The analysis of faeces revealed practically no difference between Groups A and B, and it was also found that ten of the workers in the Hygienic Laboratory of the U.S. Public Health Service who had had no known exposure to lead had small amounts of lead in the faeces. In both the garage groups the amount of lead was larger and Group D showed a larger amount than the control Group C.

The blood examination also showed no difference between the two groups of chauffeurs while the number of stippled cells in Group C was higher than in the first two groups and Group D was higher still. These results therefore indicate an incipient storage of lead in Group C and D. The findings in Group E were far more pronounced than in any of the others, over 90 per cent. of Group E showing distinct stippling.

The committee endeavoured to discover whether any cases of lead poisoning had occurred in the region where the investigation was made and where ethyl gasoline had been employed as a motor fuel for the longest time. No cases came to light after the most careful enquiry.

The presence of lead and of stippled red cells in the control garage group showed the need of an examination of the dust in that group. It is evident from the results obtained that lead is present in the air and in the dust, even when the gasoline contains no lead. The figures found ran from 0.82 mg. to 22.31 mg. per gramme of dust.

On the basis of this investigation the committee felt that the following general conclusions were justified:

1. Drivers of cars using ethyl gasoline as a fuel and in which the concentration of tetra-ethyl lead was not greater than one part to 1,300 parts by volume of gasoline, showed no definite signs of lead absorption after exposures approximating two years.

2. Employees of garages engaged in the handling and repairing of automobiles and employees of automobile service stations may show evidence of lead absorption and storage, as indicated by the lead content of the faeces and the appearance of stippled cells in the blood. In garages and stations in which ethyl gasoline was used, the amount of apparent absorption and storage was somewhat increased, but the effect was slight in comparison with that shown by workers in other industries when there was a severe lead hazard (Group E) and for the periods of exposure studied was not sufficient to produce detectable symptoms of lead poisoning.

3. In the regions in which ethyl gasoline has been used to the greatest extent as a motor fuel for a period of between two and three years, no definite cases have been discovered of recognisable lead poisoning or other disease resulting from the use of ethyl gasoline.

In view of these conclusions the committee reports that in their opinion there are at present no good grounds for prohibiting the use of ethyl gasoline of the composition specified, as a motor fuel, provided that its distribution and use are controlled by proper regulations.

The committee feels conscious of the fact that their conclusions, although based upon most careful and conscientious investigations, are subject to the criticism that they have been derived from a study of a relatively small number of individuals who were exposed to the effects of ethyl gasoline for a period of time comparatively brief when the possibilities in connection with lead poisoning are taken into consideration. A more extensive study was not possible on account of the limited time. It remains possible that, if the use of leaded gasoline becomes widespread, conditions may arise very different from those studied by them which would render its use more of a hazard than would appear to be the case from this investigation. Longer experience may show that even such slight storage of lead as was observed in these studies may lead eventually in susceptible individuals to recognisable lead poisoning or to chronic degenerative diseases of a less obvious character. In view of such possibilities the committee feels that the investigation begun under their direction must not be allowed to lapse. The respective States would be dependent upon the findings of such investigations for changes in their regulations. With the experience obtained and the expanded methods now available, it should be possible to follow closely the outcome of a more
extended use of this fuel and to determine whether or not it may constitute a menace to the health of the general public after prolonged use or under conditions not now foreseen.

Apart from the question of ethyl gasoline, it would seem from this investigation that wherever automobiles are housed together, there is an accumulation of lead dust which may prove to be a source of danger to the workers involved, in addition to the hazards arising from the production of carbon monoxide gas. The vast increase in the number of automobiles throughout the country makes the study of all such questions a matter of real importance from the standpoint of public health.

As a result of this report agreements were entered into between the producers and blenders of tetra-ethyl lead on the one hand, and the Public Health Service on the other, whereby the distributors of ethyl gasoline and the retail sellers. Tetra-ethyl lead is produced by one company only and in a factory inspected and approved by members of the Surgeon-General's Committee. The blending of tetra-ethyl lead with gasoline is done by the oil companies and only blended gasoline is sold to the trade. Every supply pipe in a filling station which delivers ethyl gasoline bears a warning sign, stating that the gasoline contains lead, is fit for no purpose except motor-car fuel, must not be used for cleansing, and that it is dangerous if spilled on the skin. Between 1918 and 1926, 94 illnesses in 72 individuals have been reported in compliance with contracts between distributors of ethyl and filling stations as to notification of all cases of illness. These cases are referred to Professor Surgeon J. P. Leake, of the Public Health Service, and the more suspicious ones have been personally investigated by him or by R. A. Kehoe. The conclusion of these two authorities is that lead was not a factor in these cases, a matter of surprise to the investigators who had expected to find some cases of lead poisoning.

Dr. Leake writes that there were 25 cases of skin disease, burns, fungus infection, eczema and dermatitis; 30 of pyogenic infection; 9 of gasoline intoxication; 5 of carbon monoxide poisoning; 2 of nephritis; 3 of arthritis; 4 of upper respiratory infection; 5 of affection of the teeth and gums; and 4 pulmonary cases; 1 bronchial pneumonia, 1 asthma, 1 tuberculosis and 1 pleurisy. There were 7 cases of inflammatory disease of the eye or the conjunctiva. The cases involving the central nervous system were 8, namely, 4 of neuritis, 1 melancholia, 1 paralysis agitans, 1 acute temporary delirium, 1 encephalitis lethargica. Finally there were 4 cases of cardio-vascular disease and 1 each of hepatitis, tonsillitis, intestinal stasis, lymphatic leukemia, and purpura hemorrhagica.

Toward the end of 1927 tetra-ethyl lead began to be imported into England and there blended with gasoline (petrol). A Departmental Committee on Ethyl Petrol of the Ministry of Health was appointed to make an exhaustive study of the possible hazards attending the various processes involved in the preparation, distribution and use of ethyl petrol and the Committee delivered its final report in 1930. The conclusions are in harmony with those arrived at by the United States Public Health Service.

Much experimental work was carried out, with regard to the detection of lead in petrol, the possibility of absorption through the skin and the danger of fumes in street traffic. The results of these experiments show that:

1. Small amounts of volatile lead and significant amounts of non-volatile lead are present in the lubricating oil of the crank cases of motor vehicles using ethyl petrol as fuel, the maximum amount of volatile lead found being approximately one-sixteenth by weight of the amount of lead tetra-ethyl in ethyl petrol. In view of the experiments conducted by Professor Dixon, there is no danger of the absorption of lead tetra-ethyl through the skin, should oil of this character remain on the hands.

2. Cylinder and exhaust pipe deposits from cars run on ethyl petrol contain only negligible traces of volatile lead, but large quantities of non-volatile compounds. Owing to the coherent nature of these deposits, there is little danger of the lead from this source getting into the atmosphere as dust.

3. There is no serious danger to health from the spillage of ethyl petrol, even in the case of confined spaces such as closed garages and repair shops, and if adequate ventilation of such premises is secured the danger from spillage is negligible.

4. If ethyl petrol were used universally the quantity of particulate lead which would be retained in the air passages and lungs of drivers under very severe traffic conditions would not be likely to exceed 0.2 mg. per day; pedestrians would retain daily in their lungs and air passages a much smaller quantity than this. On these figures, and having regard to existing
knowledge, neither pedestrians nor drivers would be likely to inhale dangerous quantities of lead even when "puffs" were blown out of the exhaust pipes of motor vehicles during the acceleration of their engines.

5. In view of the fact that a mixture equivalent to 7 c.c. of ethyl petrol was applied daily to the shaved skin of rabbits for 180 days without the occurrence of ill effects, even garage workers who are engaged on repair works or on filling petrol tanks and whose skin is therefore most likely to come into contact with ethyl petrol, cannot be regarded as subjected to any danger.

6. There is no danger in streets from the lead or the carbon monoxide emitted from the exhausts of motor vehicles.

7. The calculated amounts of lead in the air of streets and garages, based upon the amounts of carbon monoxide found by analysis therein, are in general agreement with the amounts of lead found by experiment under conditions representing a traffic block.

8. The proportion of particulate lead retained by the lungs depends upon the depth of breathing. The proportions are 16 per cent. when breathing while at rest (sitting), and 32 per cent. when breathing during gentle exercise; American investigators found that 15 per cent. of the particulate lead was retained by the lungs of men breathing normally at rest.

9. The odour of the exhaust gas produced by the combustion of ethyl petrol when diluted with air is not distinguishable from that produced by other fuels used for internal combustion engines.

Based upon these results and the experiments carried out in the United States the Committee concludes that:

1. The widespread use of ethyl petrol as a motor fuel for motor vehicles would not increase the proportion of particulate lead in the atmosphere of streets to such an extent as to constitute a risk even to the health of that part of the population which is most exposed — namely, police officers on traffic control duty and drivers of motor and other vehicles.

2. In a properly ventilated garage there would be no danger to health from the exhausts of motor vehicles, or from the evaporation of ethyl petrol owing to spillage. Even in a badly ventilated garage the danger due to spillage would not be serious. It should be stressed, however, that adequate ventilation of all garages, whether or not ethyl petrol is used, is a matter of considerable importance, and that the danger from carbon monoxide in an unventilated garage is very serious.

3. The risk arising from the absorption of tetra-ethyl lead owing to the contact of ethyl petrol with the skin is so small as to be negligible.

4. While the deposits from cylinder heads, etc., of cars using ethyl petrol contain a high percentage of lead, the quantity and nature of these deposits are such as to make them of little significance to garage workers, if due regard is had to ordinary cleanliness.

5. There is no danger to water supplies from the use of ethyl petrol.

Finally the Committee holds that there are no reasons for prohibiting the use of ethyl petrol so long as the following precautions are observed:

1. Cans and pumps should be labelled to indicate the presence of lead in the fuel and to warn the user to avoid spillage and not to use the fuel for other purposes than motor fuel.

2. The fuel should be dyed as an additional check against its use otherwise than as a motor fuel.

3. The amount of tetra-ethyl lead in the fuel sold for ordinary commercial purposes should not exceed 1 part in 1,300 parts by volume or about 1 in 650 by weight.

The most recent work (1931) on lead tetra-ethyl has been done by Kehoe, of Cincinnati, and his colleague, Thamm. In 1927 Kehoe published a paper giving the results of experiments on rabbits to compare the action of lead tetra-ethyl with that of an inorganic lead salt. He concludes that the toxicity of the former is a function of its lead content. He suggests that lead tetra-ethyl owes its toxicity to a decomposition product or products which are water-soluble and capable of coagulating proteins.

The latest work by Kehoe and Thamm discusses the absorption of lead tetra-ethyl through the skin and the fate of this compound in the body. The investigators conclude that the latter differs little from that of water-soluble lead compounds, although it does differ greatly in its ability to pass through the skin. Absorbed in this way it circulates as lead tetra-ethyl, but the greater part is rapidly decomposed by the tissues and after three to fourteen days the distribution of the lead is similar to that of other lead compounds and in its mode of excretion it does not differ from these other compounds.

Kehoe and Thamm used rabbits and applied lead tetra-ethyl to the shaved skin, preventing the animal from breathing the fumes by placing its head under a hood in a current of
air. They analysed the tissues in a steam-distillation apparatus with bromine water vapour because of the volatility of lead tetra-ethyl and its easy decomposition in the presence of bromine.

Lead was found in the carcass exclusive of the treated area of skin in amounts running from 0.96 mg. after one half-hour of skin application, to 8.24 mg. and 9.27 mg. after four hours' application. If the animals were killed promptly the greatest proportion of the lead was found in the bile and the liver, next in kidneys and spleen, but if killed after a longer period (from one to 205 days), the lead was found to have disappeared largely from the blood and organs and to be concentrated in the bones. This is similar to the fate of water-soluble lead and they believe that lead tetra-ethyl has been converted to this form. There are, however, two distinctions which may be important in human cases. More lead is found in the muscles and in the brain than is true of water-soluble compounds. The brain of an animal that lived 205 days after the experiment contained as much as that of an animal dying much earlier. Afterwards a lethal dose of lead is found in the brain, but not after small doses, for lead tetra-ethyl seems to lose quickly in the body its affinity for fatty tissue. They found it decomposing rapidly to non-volatile compounds, within the first thirty days and over one-half in the first week. From one-quarter to one-third is eliminated by the kidneys.

**Detection**

It should be fairly easy for customs authorities to detect tetra-ethyl lead in imported petrol. Similarly, it should be easy for the factory inspectorate to ascertain whether the product in question is manufactured in the country.

Different methods have been suggested by Dr. Fallenberg for this investigation and for estimating the amount of organic compounds of lead in the petrol. The most practical are the following:

**Qualitative research:** The petrol to be examined is burnt in a small lamp, the wick of which consists of a cotton thread. A large test tube full of water is held above the flame. At the end of about ten minutes there may be noticed a deposit on the foot of the test tube. This deposit is dissolved in acetic acid diluted to 30 per cent., and the solution is treated by a current of sulphuretide hydrogen. A black precipitate indicates the presence of lead. It is thus possible to detect 1 part of lead in 20,000 parts of petrol, which corresponds to 0.05 mg. of tetra-ethyl lead.

**Quantitative research:** (a) Sulphuric acid and nitric acid method: 10 c.c. of petrol are introduced into a Kjeldahl balloon flask with 0.5 c.c. of sulphuric acid and 2 c.c. of concentrated nitric acid. The flask is heated over a naked flame. After cooling the upper layer is decanted and the watery layer diluted with water. The contents of the flask are then evaporated over a naked flame. The sulphate of lead is then separated and weighed in the ordinary way. Dr. Fallenberg, however, advocates that the separation of the precipitate be effected by centrifugation in order to avoid filtrations which would be difficult in view of the very small quantities of lead involved.

(b) Permanganate of potassium and sulphuric acid method: 10 c.c. of petrol are treated in a Kjeldahl flask by 2 c.c. of a saturated solution of potassium permanganate of potassium and 1 c.c. of concentrated sulphuric acid. It is shaken vigorously while being heated for from two to three minutes in boiling water, then sodium bisulphide is added to excess. The petrol which floats on the top is removed by a separating funnel. The watery layer is transferred again to the Kjeldahl flask and evaporated. The nitrous fumes are driven off and the residue is treated with water. The lead sulphate alone remains insoluble. It is separated by centrifugation washed in alcohol, transferred to a calibrated receptacle, calcined and weighed.

It must be stated that the quantitative estimations must always be preceded by the qualitative research carried out as indicated above, that being the only method which permits of ascertaining the presence of an organic derivative of lead. It would be equally useful to ascertain the presence of chlorine or bromine which enter into the composition of liquid tetra-ethyl.

Ferreri (1928) determines the quantity of tetra-ethyl lead in the fuel by decomposing the anti-detonating agent by means of hydrochloric acid. The lead chloride formed can be weighed directly. It is also possible to transform the PbCl₂ into sulphate of lead which is then weighed.

**Hygiene**

From the hygienic point of view it would be essential so to organise production that the worker is removed as far as is possible from inhalation of toxic fumes, and to draw the attention of garage workers and mechanics to the danger of escape of gas, which makes it necessary to ensure adequate ventilation in repair shops and garages. It is, however, important to draw the attention of health experts in the various countries to the problem in question in order that they may follow...
closely production of tetra-ethyl lead where such occurs as well as the commercial manipulation of petrol containing this product. It is commonly known that the latter is now sold in a concentrated form and under fancy names invented by the selling agents who may themselves mix the product with the petrol.

In Germany there is now found on the market petrol mixed with iron carbonyl (see that article) under the name of "Motylene".

In Russia olate of lead is used and has been successfully employed during an aviation race. This product, however, must be mixed with petrol in the proportion of 1 per cent., which would increase the efficiency of the motor from 5 to 7, but also increases the danger to the public. The product in question is easily prepared and is affirmed to be non-poisonous (?)

R. A. Kehoe, Medical Director of the Ethyl Gasoline Corporation, U.S.A., has formulated the following rules for refineries and depots where the blending of tetra-ethyl lead with gasoline is done.

"Ethyl fluid is poisonous when it enters the body: it may enter by contact with the skin, through the mouth, or by inhalation through the lungs. It is essential that workers be equipped with a separate and complete change of working clothes including boots or shoes, rubber and canvas gloves, and a rubber apron, and that these clothes should be laundered daily. It should be insisted upon that at the end of the working period each employee bathe thoroughly with soap and warm water. He should be supplied with an individual cotton towel. If there is contact with ethyl fluid he should at once wash the skin with kerosene and then with soap and water. Respirators containing activated charcoal are to be used whenever the vapour of ethyl fluid is present in the air. Mixing operations should take place in an open place or in one provided with forced downward ventilation and on a floor which can be flushed immediately in case of spilling. The same men should be employed on each operation at all times."

"No cars of ethyl fluid should be unloaded until they have been inspected for leaking drums or spills. In case these are found they should be carefully cleaned up and the car properly ventilated until free from ethyl vapour. Drums should be stored with the opening up and should be carefully inspected for leaks before storing. Operations should cease immediately when leaks occur and repairs are to be made. Spilling of ethyl fluid should be avoided, and if it occurs the fluid should be immediately dissolved in kerosene and then flushed with water or else neutralised with kerosene containing 2 per cent. sulphuryl chloride or a thin paste of bleaching powder in water."

Recently (1926) Ferreri suggested the use of metallic naphthenates which are easily soluble in petrol. During refining of Russian petrol, treatment by sulphuric acid is followed by neutralisation with caustic soda and washing in alkaline water. After being left for some time the lyes separate out in three layers; one, the lightest, consists of mineral oil, and the two others of a paste-like soap and a solution of sulphate of sodium. The soap is a mixture of sodium naphthenates which easily furnish free naphthenic acids utilised in the preparation of different naphthenates. They are used as drying agents (varnish), for the preparation of imitation objects, for impregnating wood, and mordanting in the dying industry, etc.

There has also been proposed diethyl of selenium or of tellurium which, like tetra-ethyl lead, are dissolved in the same substances. It is, however, probable that their toxicity is as high as that of tetra-ethyl lead.

**LEGISLATION**

As regards legislation, the only measure passed so far is the Swiss law (Ordinance of 7 April 1925), in accordance with which petrol may not contain any compound of lead tellurium, selenium, or other compounds possessing harmful properties.

As regards notification or legal compensation for poisoning by this lead compound, the measures passed in regard to lead poisoning in general apply when the formula is that adopted by English law or when it comprises the expression "lead compounds".

**BIBLIOGRAPHY**


Textile Industry


A rapid survey of problems connected with weaving and knitting is given in this article. Spinning is dealt with in articles "Wool", "Cotton", "Silk", "Flax" and "Jute".

The manufacture of textile fabric is simply the regular interlacing of two series of perpendicular, longitudinal or warp, and transverse or weft threads. The operation takes place on the weaving loom, on which the warp threads are stretched, parallel, between two cylinders, one of which supplies the thread for weaving, while the other is for rolling up the fabric. When weaving the fabric each weft thread is passed alternately above and below various warp threads across the whole width of the fabric. In order to accomplish this, the warp threads are drawn into two series, so forming an angle, along which is thrown the shuttle containing the weft thread which unwinds as the bobbin containing the thread is made. When weaving, the fabric is passed alternately above and below various warp threads across the whole width of the fabric. In order to accomplish this, the warp threads are drawn into two series, so forming an angle, along which is thrown the shuttle containing the weft thread, which unwinds as the bobbin contained in the shuttle unrolls. After each passage of the shuttle the warp threads are combed by a comb or beam, which acts in such a way as to thrust home the weft thread into the angle formed by the two series of warp threads.

The weaving loom in use to-day in the industry is machine driven; it considerably lightens the work of the weaver, which now consists in supervising the working of the loom, piecing broken threads, and replacing the cops in the shuttles; these last two operations necessitate stopping the machinery. However, there are more up-to-date machines in which a mechanical device automatically replaces the cop in the shuttle without stopping the machinery, should a weft thread break or the shuttle become empty. The quality and appearance of a tissue depend on the nature and fineness of the warp and weft threads, and on the closeness of their apposition, as well as on the various arrangements for interlacing the warp and weft threads, so producing patterns which result from the way in which the warp threads are drawn upwards or downwards before the interweaving of the weft threads. Certain so-called fundamental patterns in linen, batavia or twill serge or satin, are obtained by means of combinations which may be endlessly varied, to produce a diversity of patterns, either striped, check, damasked or ribbed. Special machinery is employed for weaving complicated and figured patterns.

Figured fabrics, which need a great number of strips, are made to-day automatically on the jacquard loom, which has taken the place of the draw loom. In the jacquard loom the pattern desired is obtained by means of cards, perforated beforehand according to the pattern required; they form a continuous belt, which unrolls on a quadrangular block, making one-quarter of a revolution for each weft thread, so bringing the desired pattern into being. A machine fitted with needles and a spring coaxes the drawing upwards and downwards of those warp threads which correspond to the perforations of the card, and prevents displacement of those weft threads which correspond to the non-perforated parts of the card.

Weaving is preceded by a number of preparatory operations, which include making ready or spooling the weft threads on the cops in order to prepare the weft; moistening the cops with clean water or soapy water so as to obtain closely woven fabrics; winding skeins of thread on to bobbins in order to prepare the warp; twisting or warping by simultaneously winding and gathering together threads supplied by a certain number of the bobbins; and dressing or sizing the warp threads. Mention should also be made of the operation of punching the cards which are used on the jacquard loom.

Fabrics, when taken off the loom, undergo a process of repair to remove any defects in the woven piece, such as tears or rents, flaws in the weaving, or irregularities of design.

The fabrics next pass on to other operations, the object of which is to give them the quality required by the use to which they are to be put; dressing, properly so called, which includes the incorporation with the fabric of various thickening substances, such as starch, faecula, dextrin, animal glue, fat substances, oil or glycerine, in order to give a substantial feel to the fabric; or kaolin, talc or barium sulphate, to give weight or resistance; preparation, by means of mechanical operations, such as pressing in the hydraulic press, between calender rollers, trimming, goffering, humidifying, steaming, sponging, or drying on tenterframes.

During the last few years, the chemical industry has put on the market certain moistening agents prepared by synthetic means, used to accelerate the operations of bleaching, carbonisation, mercerisation and dressing.

Hosiery includes the manufacture of articles in knitted fabric or in tubular fabric (jersey), from a few inches in diameter to two or three yards, made on a frame the needles of which are arranged round a circular disc. Knitted hosiery is now made on a knitting machine, which can turn out the knitted fabric either in strips or tubes as desired. For the manufacture of fancy articles the machines are fitted with mechanical devices, e.g. fringing apparatus.
They go back to the year 1910, and cover a total of 4,950 wage earners, of whom 1,335 were men. The frequency of various kinds of sickness among the men and women is indicated in the two following tables:

### MEN

<table>
<thead>
<tr>
<th>Cases of sickness (per 1,000)</th>
<th>Total</th>
<th>Under 15 years</th>
<th>15-34 years</th>
<th>35-54 years</th>
<th>55-74 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of persons under observation for a year</td>
<td>1,335</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases of sickness</td>
<td>228.4</td>
<td>227.5</td>
<td>226.8</td>
<td>334.3</td>
<td>666.7</td>
</tr>
<tr>
<td>Nervous system</td>
<td>5.2</td>
<td>5.5</td>
<td>5.5</td>
<td>2.9</td>
<td>16.7</td>
</tr>
<tr>
<td>Respiratory system</td>
<td>32.0</td>
<td>31.2</td>
<td>30.0</td>
<td>55.2</td>
<td>50.0</td>
</tr>
<tr>
<td>Digestive system</td>
<td>63.7</td>
<td>61.5</td>
<td>60.9</td>
<td>38.1</td>
<td>100.0</td>
</tr>
<tr>
<td>Tuberculosis (all forms)</td>
<td>12</td>
<td>—</td>
<td>5.5</td>
<td>32.0</td>
<td>—</td>
</tr>
<tr>
<td>Circulatory system</td>
<td>1.5</td>
<td>—</td>
<td>3.2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Rheumatism, articular and muscular</td>
<td>25.5</td>
<td>—</td>
<td>14.2</td>
<td>49.4</td>
<td>65.7</td>
</tr>
<tr>
<td>Poisonings</td>
<td>2.3</td>
<td>—</td>
<td>1.1</td>
<td>9</td>
<td>16.7</td>
</tr>
<tr>
<td>Accidents (absolute figures)</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### WOMEN

<table>
<thead>
<tr>
<th>Cases of sickness (per 1,000)</th>
<th>Total</th>
<th>Under 15 years</th>
<th>15-34 years</th>
<th>35-54 years</th>
<th>55-74 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of persons under observation for a year</td>
<td>3,615</td>
<td>44</td>
<td>3,113</td>
<td>412</td>
<td>45</td>
</tr>
<tr>
<td>Number of cases of sickness</td>
<td>541.6</td>
<td>315.2</td>
<td>529.4</td>
<td>648.1</td>
<td>630.4</td>
</tr>
<tr>
<td>Nervous system</td>
<td>15.2</td>
<td>—</td>
<td>11.6</td>
<td>43.7</td>
<td>21.7</td>
</tr>
<tr>
<td>Respiratory system</td>
<td>62.2</td>
<td>62.2</td>
<td>56.5</td>
<td>89.8</td>
<td>105.7</td>
</tr>
<tr>
<td>Digestive system</td>
<td>119.8</td>
<td>65.2</td>
<td>123.0</td>
<td>101.9</td>
<td>105.7</td>
</tr>
<tr>
<td>Tuberculosis (all forms)</td>
<td>8.0</td>
<td>—</td>
<td>8.4</td>
<td>7.3</td>
<td>—</td>
</tr>
<tr>
<td>Circulatory system</td>
<td>14.9</td>
<td>22.7</td>
<td>13.3</td>
<td>39.1</td>
<td>—</td>
</tr>
<tr>
<td>Rheumatism, articular and muscular</td>
<td>26.3</td>
<td>—</td>
<td>20.6</td>
<td>88.0</td>
<td>65.0</td>
</tr>
<tr>
<td>Poisonings</td>
<td>0.6</td>
<td>—</td>
<td>0.3</td>
<td>2.4</td>
<td>—</td>
</tr>
<tr>
<td>Accidents (absolute figures)</td>
<td>49</td>
<td>—</td>
<td>42</td>
<td>7</td>
<td>—</td>
</tr>
<tr>
<td>Genito-urinary organs</td>
<td>30.6</td>
<td>—</td>
<td>41.4</td>
<td>31.0</td>
<td>—</td>
</tr>
<tr>
<td>Anaemia</td>
<td>83.8</td>
<td>45.5</td>
<td>92.8</td>
<td>29.1</td>
<td>—</td>
</tr>
</tbody>
</table>

As regards mortality, the most important statistics are those published in Great Britain referring to the period 1921-1923. These statistics are based on the assumption that the general mortality of all occupied and retired males, taken as the standard, is represented by 1,000. The various categories of workers dealt with include weavers in the cotton industry, those in the wool and worsted industry, and weavers of other textile fabrics, hosiers and knitters, dyers, scourers, calenderers and finishers.

The following table indicates the death rate for these various categories of workers from certain causes:

<table>
<thead>
<tr>
<th>Causes of death</th>
<th>Total number of deaths from all causes</th>
<th>Total of occupied and retired workers</th>
<th>Weavers of cotton</th>
<th>Weavers of wool and worsted</th>
<th>Weavers of other textile fabrics</th>
<th>Hosiers and machine knitters</th>
<th>Dyers</th>
<th>Scourers and calenderers and finishers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of deaths from all causes</td>
<td>1,000</td>
<td>1,048</td>
<td>1,082</td>
<td>888</td>
<td>929</td>
<td>1,304</td>
<td>1,015</td>
<td></td>
</tr>
<tr>
<td>Influenza</td>
<td>36.4</td>
<td>39.3</td>
<td>10.3</td>
<td>14.9</td>
<td>26.5</td>
<td>65.3</td>
<td>33.8</td>
<td></td>
</tr>
<tr>
<td>Tuberculosis (all forms)</td>
<td>177.3</td>
<td>126.7</td>
<td>226.8</td>
<td>173.6</td>
<td>161.1</td>
<td>218.9</td>
<td>178.3</td>
<td></td>
</tr>
<tr>
<td>Syphilis</td>
<td>27.1</td>
<td>16.6</td>
<td>7.8</td>
<td>7.7</td>
<td>23.5</td>
<td>25.2</td>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>128.4</td>
<td>128.1</td>
<td>129.3</td>
<td>106.6</td>
<td>119.1</td>
<td>146.6</td>
<td>136.2</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>142.2</td>
<td>14.4</td>
<td>31.3</td>
<td>9.0</td>
<td>12.4</td>
<td>19.5</td>
<td>17.3</td>
<td></td>
</tr>
<tr>
<td>Cerebral haemorrhage</td>
<td>44.9</td>
<td>73.7</td>
<td>41.2</td>
<td>65.7</td>
<td>48.8</td>
<td>48.2</td>
<td>51.1</td>
<td></td>
</tr>
<tr>
<td>Circulatory system (diseases of)</td>
<td>132.2</td>
<td>130.7</td>
<td>225.2</td>
<td>174.0</td>
<td>142.4</td>
<td>209.3</td>
<td>178.7</td>
<td></td>
</tr>
<tr>
<td>Respiratory system (diseases of)</td>
<td>131.7</td>
<td>163.1</td>
<td>102.0</td>
<td>113.9</td>
<td>113.1</td>
<td>238.8</td>
<td>160.8</td>
<td></td>
</tr>
<tr>
<td>Digestive system (diseases of)</td>
<td>69.5</td>
<td>67.8</td>
<td>82.1</td>
<td>48.4</td>
<td>67.3</td>
<td>83.6</td>
<td>53.9</td>
<td></td>
</tr>
<tr>
<td>Chronic nephritis</td>
<td>34.3</td>
<td>42.9</td>
<td>53.2</td>
<td>50.2</td>
<td>47.1</td>
<td>48.2</td>
<td>50.2</td>
<td></td>
</tr>
<tr>
<td>Suicide</td>
<td>24.3</td>
<td>33.5</td>
<td>7.9</td>
<td>12.2</td>
<td>55.2</td>
<td>23.1</td>
<td>11.9</td>
<td></td>
</tr>
<tr>
<td>Accidents</td>
<td>49.3</td>
<td>11.0</td>
<td>33.5</td>
<td>12.6</td>
<td>25.0</td>
<td>50.0</td>
<td>19.0</td>
<td></td>
</tr>
</tbody>
</table>
PATHOLOGY

No important occupational condition of ill-health derives from the operations of weaving and accessory processes. This is particularly true in regard to those who work in factories where up-to-date technical installations create a satisfactory and hygienic environment, especially as regards temperature and humidity.

The general health of these workers is a reflection of their social surroundings and their living conditions, but especially of the technical organisation in the factory where they work. Indeed, it is quite usual to find different hygienic conditions in the same industry according to whether the situation is in the country, in a big industrial centre, or in a semi-industrial and semi-agricultural area.

Weaving, and particularly its accessory operations, may cause dermatitis, complicated or not with eczema, among which may be mentioned dermatitis due to tartrate of potassium and antimony, characterised by a papulo-pustulous type. The radical antimony combines with the tannin contained in the solution used as a mordant before the dyeing of the fabrics, and eliminates the tartrate (Selisskij, 1927; Lagoviner, 1928). In the cases under observation there was cyanosis of the skin, and the dermatitis, as a rule follicular, developed into atrophy and sometimes necrosis. The lesion was situated on the extremities, the penis and sometimes the upper lip. In the course of eighteen months, Selisskij noted 290 cases of dermatitis, including relapses. In Japan, Bogo Koinuma in 1926 described a form of eczema (Mizumushi) peculiar to weavers; cutaneous troubles caused by chromates have been reported among fabric dressers and dyers.

Oppenheim draws attention to the formation of callosities, due to the handling of rough fabrics or irritant colouring agents.

Dust, high temperature and humidity explain the frequency of respiratory and rheumatic affections and disorders due to "chills".

A disease considered to be peculiar to cotton weavers was reported in 1913 by Collis. A great number of workers in Lancashire suffered from coughs, feverishness and attacks of asthma in mills where chloride of zinc was not used for preventing the formation of moulds on the warp threads. Moulds of the "aspergillus" group were thought to be the cause of the outbreaks; the cases recovered after a period of varying duration of absence from work, or else persisted in a chronic form. Middleton reported as a complication of this pulmonary affection a form resembling tuberculosis. In other cases the symptoms were so similar to the clinical picture of tuberculosis as to make a differential diagnosis with tuberculosis a difficult matter.

A noteworthy incidence of cortico-pleuritic forms was reported by Lo Caso in 1929. Badham in 1928, as the result of an enquiry into the conditions of health among textile workers in Sydney, recommended revision of the regulation in force at that time regarding the degree of humidity and heat to be permitted in the industry in question.

Standing while at work may easily bring about disorders of the venous circulation, causing varicose veins; Suguiria in 1930 and Konishi in 1929 studied in Japan the frequency of varicose veins among weavers.

Anaemia appears to be equally common (Konishi, 1929); as are also lesions of the locomotor apparatus among the young men who have to do strenuous work; tenovaginitis occurs among the women workers in the hosiery trade employed in drawing the stockings out of the frames, due to this work constantly bringing into action the long adductor and short extensor muscles of the thumb; modifications of the foot and of the knee have also been reported by Aisenstein in 1927-1928.

Workers who have to carry or push heavy weights — especially women workers, including those in the hosiery trade who handle the hot metal or wooden moulds with which they push with the abdomen against the table — often complain of various troubles such as enteroposis, and, in particular, disorders of the abdominal organs.

Supervision of several looms at once, especially in the weaving of ribbons and lace-making, requires close attention, which is generally very exhausting and may in time set up nervous disorders. Observations made in Russia on workmen who have passed from tending two looms to tending three have brought to light facts which demonstrate the early development of the phenomena of fatigue, the cause of which is favoured by bad lighting arrangements, by unhealthy temperature, humidity in the workplaces, and also by exhaustion resulting from accessory forms of work. But the adoption of hygienic precautions would appear to prove that the change over to the tending of three looms need
not necessarily be attended by any serious risk of over-strain for the worker (Rosenbaum, Riwelina, Belogorets and Seletzkaja).

Tending a number, sometimes very considerable, of looms—twenty, or thirty, or even forty, rendered possible by the most up-to-date technical plant—may lay the foundation of various disorders, chiefly fatigue. However, Koelsch considers that the movements required for tying the threads do not cause any increase in invalidity, and especially in gastro-intestinal troubles, reported among weavers.

In 1930 Kopelowitsch described numerous cases of nervous diseases among the workers in a stocking and fabric factory. They included forms of hyperthyroidism, chiefly among the women; and of goitre, which he correlated with the conditions of the individual workers, as regards constitution and sexual life, and with their working conditions, lack of hygienic measures and fatigue.

Another source of nervous fatigue is noise, which is considerable in weaving sheds, and also vibration caused by the movement of heavy and noisy machinery.

Cases of conjunctivitis have been observed in weavers, and attributed to certain colours used in dyeing.

Although Waither has emphasised a heavy incidence of cases of short-sight among weavers, amounting to 75 per cent., few of whom had suffered from short-sight when they started as weavers, Roth, on the contrary, only reported an incidence of 7-8 per cent. Both acknowledge that it was only a question of short-sight of a medium degree—3 D at the maximum. Obviously short-sight is aggravated by bad lighting, which is more often than not the case when work is carried on at home (Netolitzky and others).

Ocular fatigue in the hosiery industry was the subject of an extremely interesting article by Weston in 1927.

Disorders of hearing are represented by diminution in auditory acuity, which may be so serious as to develop into deafness, due to noise, and by otitis caused by certain fungi conveyed in tiny drops of starch thrown into the air and localised in the external auditory meatus.

This bad habit of shuttle kissing, called in French "baiser de la mort", — the kiss of death — should be mentioned. It consists in drawing the thread into the mouth through the eye of the shuttle, when a new thread is put into the shuttle, or when the thread breaks, especially in mills where a fine thread is used. This habit has long been regarded as constituting an important source of risk to the worker. A little wire hook should be used to pass the new thread through the eye in the shuttle; but the worker finds it quicker and more convenient to have recourse to aspiration with the lips. Since this operation may take place every ten minutes, this habit, which must be considered as distinctly unhygienic, becomes a source of such cutaneous and buccal diseases as tuberculosis and syphilis, when different workers succeed each other at the loom.

Various new types of shuttle with mechanical aspiration, and especially the introduction of automatic weaving are fast doing away with manual operations in charging the shuttles and drawing the threads into position.

Risk of lead poisoning may be so common in work on the Jacquard looms with lead counterpoises, has now become very rare. Cases of lead poisoning have been reported among the lace makers who handle products impregnated with such salts of lead as the acetate or chromate.

In the accessory operations of dyeing, dressing and printing, the workers are exposed to the harmful effect of air which is hot and damp, or to that of certain substances which are used. During bleaching, a source of danger may be represented by acid fumes (sulphurous anhydride); during gassing by carbon monoxide if the operation is not carried out with complete aspiration of the gases of combustion.

Injuries which may be attributed to colours are fairly rare, as the use of toxic products, with a lead or arsenic basis, has now been almost completely suppressed. Besides, the colours are used nowadays in very weak solution. Yet in persons who are specially predisposed it is sometimes possible to observe injuries to the skin, such as eczema, or to the teeth, or cases of conjunctivitis.

Mention should be made of the special work of repairing, which is liable to cause ocular fatigue, with accommodative asthenopia, watering of the eyes, photophobia, conjunctival congestion, and, often, sub-orbital neuralgia. The sitting position which the women are obliged to maintain exerts an injurious repercussion on the neuro-muscular system, setting up fatigue, spasms and muscular cramps, of which cramp of the fingers is the most frequent. This is characterised by a painful contraction, involuntary and temporary, of the muscles of the
The social question of women's work in the textile industry has resulted in a large number of enquiries in which there is some divergence in the conclusions drawn. Although the writings of Hirsch and others (see article "Women's Work") emphasise the injurious effect of this work on the female organism, on pregnancy and on the offspring, the contributions of Holtzmann in 1928 and of Geller in 1929 arrive at less unfavourable conclusions.

Holtzmann, who carried out his observations at Lorrach and at Friburgh reports that premature confinements and miscarriages are less common among these women workers than among the rest of the female population of the same town. It is undeniable that these favourable results are accounted for by the benefits of social insurance, with help during pregnancy and at confinement. The average life of women who are employed in the textile industry is shorter than that of the agricultural population, for the reason that persons who have not got a robust constitution turn to industry. The average age at death for women who have been engaged in industry and in agriculture is lower than that for men similarly engaged, because in the case of women the fatigue of housework is added to occupational fatigue. But women in industry have better social conditions than women employed in agriculture. This fact also exerts an influence on the probability of survival for infants. Gynaecological diseases which might be attributed to occupational strain are not unduly frequent.

Geller has made a study of the morphology of the pelvis in women employed in the textile industry, including 2,073 women workers between the ages of fourteen and twenty, and 633 who were pregnant. The work would appear to have no effect on the diameter of the pelvis, nor would it seem that the pregnancy was affected. Women employed in the textile industry had fewer still-born children. Geller considers that it is not hard work which is a danger to these women, but rather the fact that the pregnant woman stands too long, in hot, moist, noisy surroundings, employed on work which requires close attention. Among the women who are pregnant Geller often found a poorer state of health than among the others. Whereas the work does not have a directly injurious action on the product of conception, it certainly does have an injurious effect on the woman herself, in lowering her capacity for child-bearing and for nursing her child at the breast. Finally, in 1927, Alesker, Slatopolskaja and Korolev observed among the young Russian women who worked at weaving a hypo-evolution of the genital organs.

It must, however, be admitted that, in comparison to what went on in the past, the sanitary conditions for weavers, especially women and young workers, have been greatly improved, thanks to progress in industrial technique with mechanical devices, and to the measures of social relief adopted.

The risk of accidents should not be overlooked, although as a rule the textile industry ranks almost lowest among factory occupations classified in order of accident frequency.

In one factory it was the duty of a workman to nitrate a fabric which had been dyed with "oxydiaminogen OT". Contrary to the instructions received, he used a concentrated solution of nitric instead of a dilute solution, thus causing a liberation of nitrous fumes, with fatal poisoning for the worker.
Weaving sheds, and places where accessory operations take place, must fulfill the requirements laid down for the general hygiene of factories (see article "Industrial Hygiene (Workshops)"). Four points are of particular importance, viz., ventilation, cooling, and humidification of the air, and lighting.

As is well known, textile fibres are hygroscopic, and, in order to work them easily, the temperature and hygroscopic condition of the atmosphere must be just right. It is likewise known that work on rough fibres, in an atmosphere that is too dry, causes static electricity, which, besides making the fibres stand erect, may also be the cause of very serious accidents from fires and explosions.

For these reasons artificial humidification of the air in textile mills is necessary if the air of the district in which the mill is situated is not sufficiently damp — and it is not, as a rule, during the hot season. The disadvantages of such an atmosphere and its effects on the human organism are referred to in the article "Air: Hot and Humid Atmospheres". These have led the legislator to demand adequate ventilation in weaving sheds in order to prevent any excessive rise in the temperature.

It is also noted in those articles dealing with the various textile fibres that formerly, in the fear of draughts, special arrangements were made to avoid all contact of the sheds with the exterior air. At this period the sheds were under plus pressure because damp air was introduced into them, instead of being under minus pressure, due to evacuation of the hot air to the outside.

The solution of the problem of humidification has thus become a more difficult matter, for the engineer must consider simultaneously ventilation, humidification and cooling.

Modern technique has nevertheless provided a solution of the problem; and it is now possible to obtain ventilation and the evaporation of water necessary for cooling and humidification by means of systems which may be briefly stated to be based on the following principles:

- Incorporation of water with air by prolonged contact with the liquid and vapour, either by stirring or by close mixing; the air is then distributed in the sheds from saturators, atomisers or supersaturators;
- Production of humidification and ventilation by various vaporising apparatus.

Saturators for humidification and cooling utilise air which only carries the quantity of water corresponding to its point of saturation. Atomisers combine the two operations in one: in a first stage a preliminary preparation analogous to that of the saturators takes place, wherein the air evaporates a quantity of water corresponding to its point of saturation; in a second stage the completion of the preliminary stage takes place in the weaving shed, for the air carries along, in the form of vapour, atoms of water which are ready for a second evaporation.

Where vaporisers are employed, the humidification is carried out in the shed. Ventilation accompanies and precedes the evaporation of the water. The work is carried out by quite distinct apparatus.

It is known that each textile fibre possesses a maximum hygrometric state, and that inside a weaving shed it is forbidden to exceed a temperature corresponding to that which exists outside, in the shade, with northern aspect and at 2 o'clock in the afternoon, when this temperature reaches at least to 28° C. and a humidity of 45-50 per cent.

The amount of fresh air required and the quantity of water which must be evaporated depend: on the maximum humidity which the textile work can bear; on the temperature, which must not be exceeded inside the shed; and on the external conditions of warmth and humidity under which these required results have to be obtained.

At the present time, there are available apparatus which make it possible to obtain humidification without ventilation, or vice versa, or even ventilation and humidification combined. The air is at the same time washed and then passed in at the desired degree of humidity. The humidification also can be modified, according to requirement, as well as the speed of the incoming air. It is even possible to unite in a single process heating by ventilation and humidification. A quite simple apparatus provides a record at any moment of the degree of humidity by using psychrometers, of the amount of carbon dioxide in the air of the weaving shed, or even of the degree of comfort by use of the katathermometer.

Humidity is definitely recognised as essential in the textile industry; a condition which is hygienically favourable facilitates the formation of "grains" in the classic fabrics; the
fabric has a better appearance, and is thick; the warp unrolls more easily, and the threads are less brittle; thread that is sized or taped breaks like glass if it is too dry; on the other hand it must not be too damp.

Temperature does not play an important part in weaving, which is contrary to what holds good for spinning; a temperature of about 18°C is necessary for assuring the best output from the worker. It might be said in a general way that a relative humidity of 70–80 is indicated for weaving cotton on the ordinary looms, and a temperature of 75–80 is indicated for weaving cotton, flax, hemp and jute.

According to Neu, in places where cotton, flax, hemp and jute are prepared, on an average, a temperature of 18°C may be required with a relative humidity of 65; in weaving sheds, a temperature of 18°C with a humidity of 70–85, for cotton according to the kind of loom used, of 75–85 for flax, and of 80 for jute and hemp. For both wool and silk, a temperature of 18°C and a humidity of 60 during preparation, and of 65–70 for weaving is required.

As regards lighting, a general uniform system of lighting should be insisted upon, with luminous sources of 100–150 W. for sheds where cops and bobbins are wound, work at weaving looms, hosiery knitting machines, and other machines. Lighting must be concentrated for places like warps, bobbins are prepared, or sizing and taping machines, and for Jacquard looms.

The best lighting is that of 40–50 lux for the tapping machines; 50–60 for winding cops and bobbins; 50–80 for warp beams and other machines; and 50–100–120 for the weaving machines.

Concentrated light should be distributed after a very careful study of the particular conditions of the workplace. The arrangement of the machines — such as taping and sizing machines — must be taken into account, considering on the level as well as in elevation and likewise the vertical and horizontal surfaces of Jacquard looms, in order to prevent production of shadows, unequal lighting, hard shadows and dazzling.

Account must be taken of the delicate nature of the work done, e.g. on the Jacquard looms, of the colour of the fabric, since with black tints stronger light is required, and of the presence of great cumbersome machines liable to intercept a large part of the luminous rays.

Whereas for hosiery, general, uniform, but intense lighting may be right, for extremely fine work and mending concentrated light is necessary.

Weaving sheds as a rule have natural lighting coming from the roof — saw roofs; but up-to-date systems tend more and more to attain this end with rows of windows. In this case, suitable measures must be taken to assure for the workers a stable, constant, soft and restful light.

In brief it is essential to recall provision of measures for preventing shuttle kissing; for assuring good individual hygienic conditions for the workers, conditions which must vary according to the different kinds of accessory work and are too numerous to enumerate here. Fatigue due to standing may be overcome by placing seats at the disposal of the workers whenever it is possible. For those engaged on repairing of fabrics, tables or benches should be provided, and special devices (Blin and Blin) calculated to reduce troubles arising from bad posture and manner of working.

Suitable measures must also be taken for the evacuation of residual water (see article "Industrial Waste Waters" and the articles dealing with the various textile fibres).

LEGISLATION

In Germany, youths under sixteen are excluded from workshops where combing is done, and from other premises where dust is liberated; in Belgium, those under fourteen are excluded from spinning-mills, cotton-wool factories, and from accessory processes connected with filamentous material, from workplaces where dust is liberated and there are no mechanical means for its elimination; in Spain, boys under sixteen and women under twenty-one are excluded from the process of singeing threads, if the products of combustion are given off freely into the workplace; in the United States (New Jersey), youths under sixteen are excluded from every industry where vegetable dust is liberated in harmful quantities; in France, women and boys under eighteen are excluded from the singeing and gassing of threads; the gases of combustion are given off freely in the workplaces; from the manufacture of painted fabrics in workplaces where toxic materials are employed; from the carbonising of wool and cloth by the damp process, where there is liberation of acid fumes; boys under eighteen from dye works where toxic products are used; and from bleaching linen, when chlorine or sulphurous acid is given off.
In Great Britain, the Regulations of 1929 on artificial humidification in cotton weaving permits as the maximum limit of temperature 72.5° F. (22.3° C.) with the wet-bulb thermometer, corresponding to a relative humidity of 75-80° F. The previous Regulations allowed a maximum limit of 75° F. (24° C.) and it is of interest to emphasize the fact that this limit had previously been 28° C.

The new Regulations provide for the cessation of all work when the wet-bulb thermometer reaches 80° F. (26.6° C.), and authorise the workers to leave the sheds until the temperature of the air can be adjusted to the maximum limit allowed.

Pulmonary affections, and cases of poisoning by arsenic or mercury among printers of fabric are subject to compulsory notifications in the Netherlands. Deafness caused by noise, and short-sightedness due to inadequate lighting are compensated in Bulgaria; diminution in auditory acuity on account of noise, varicos veins and ulcers on the leg, flat foot and knock-knees among weavers, are compensated in the U.S.S.R.

Deafness caused by noise, and short-sightedness are especially prevalent in the General Public Health Department, In a pure state it is a silvery white metal, soft and malleable like lead, which melts at about 300° C. It becomes volatilised slightly above its melting point, and boils at about 1,700° C. In the molten state it is black on account of formation of oxide.

Buschke has drawn attention to the similarity between thallium and lead, both from the point of view of atomic weight and from that of biological reaction (acetate of lead, like acetate of thallium, produces amongst rats whitening of the hair, as well as allergic reactions and derangements of growth). Thallium is readily oxidised on exposure to air, and liable to attack by carbon dioxide. It dissolves easily in nitric and sulphuric acid and less readily in hydrochloric acid. It combines with chlorine, bromine, iodine, sulphur, selenium and tellurium. It is attacked by alcohols (amyl-alcohol and methyl-alcohol), and the ethers, with formation of organic combinations. It provides two series of salts: thallous and thallic salts.

The raw materials required for the preparation of thallium are especially the residues of zinc, pyrites and sludge from lead chambers. In roasting pyrites in order to obtain sulphur dioxide, thallium passes into the sludge and dusts of the lead chambers. Zinc-bearing pyrites also contain thallium, which passes off in solution with zinc sulphate, when the product is washed with sulphuric acid for the recovery of zinc. The sludges and dusts are extracted by means of boiling water and the clarified liquid is treated with concentrated hydrochloric acid, which precipitates thallium chloride. The latter is finally transformed into sulphate, from which the thallium is pre-

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**Thallium**

French and German: **Thallium.** — Italian: _Talio_. — Spanish: _Talio_.

**Technical Data**

This product (symbol TI), discovered in 1861 by means of the spectroscope by Crookes, and in 1862 by Lamy, in the sludge from lead chambers, is a fairly abundant metal: found in nature in small quantities, in a state of salts in combination with other metals in various ores: _Crookerite_ (copper, silver and thallium selenide), _Lorandite_, the _Hutchtsonite_ of Lengebach, etc. Small traces of thallium are still found in the potassic salts of Stassfurt, in hematite, in manganese, zinc, cadmium, bismuth and platinum ores, in native sulphur, and especially in pyrites, etc.

In a pure state it is a silvery white metal, soft and malleable like lead, which melts at about 300° C. It becomes volatilised slightly above its melting point, and boils at about 1,700° C. In the molten state it is black on account of formation of oxide.

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pared either by means of zinc or by electrolysis. Thallium may be obtained in the same way from solutions of zinc sulphate.

Thallium is especially utilised in the state of salts. Whilst the acetate is very much used as a depilatory in ointments and as a product for destruction of rats (Céliopaste), the carbonate of thallium is used in the glass industry, in the manufacture of lenses, coloured glasses, and imitation precious stones; in the making of fireworks, manufacture of Bengal lights, etc. The chloride is utilised in the manufacture of Tungsten lamps, and as a catalyst for the chlorination of organic substances. The nitrate is used with barium sulphate to give phosphorescent colours (greens and yellows). The hydrate serves for impregnation of paper utilised in detection of ozone and sulphuretted hydrogen. The nitrate and sulphate are also utilised in chemical analysis in order to separate and measure chlorides, bromides and iodides.

**TOXIC ACTION**

Thallium is excessively toxic, and the acid is more toxic than the salts. This toxicity has for long been known, thanks to the experimental researches of Stricker (1865), Marmé (1867). Rabuteau (1874), Blake (1890), and Richet (1899). Lutz, resuming this research in 1928, has, with a daily injection of 0.2 c. cm. of a 1 per cent. solution of commercial salts of thallium, caused the death of animals in a week with cramp and diminution of weight (two-thirds of the original weight).

Lesions obtained by various research workers are as follows: atrophy of the skin and subcutaneous tissue, of the sebaceous and sweat glands, with hyperplasia of the corneal layer, degeneration of the roots of the hair (Manioli) and alopecia (Olivier, 1927; Insabato, 1927), bronchitis, bronchial pneumonia, stomatitis, venous stasis of the stomach, formation of hyperkeratotic papillomata of the cardiac region of the stomach (Olivier, 1927; Hecke, Leigheb, 1928), catarrh of the digestive system, vomiting, diarrhoea, digestive hemorrhage (Greving, Gagel, Hecke), degenerative and necrotic changes of the kidneys, oligocytthesis, pseudo-leucocytosis and eosinophilia, changes in the cell islets of Langerhans, in the suprarenal, sexual and thymus glands, congestion of the ovaries, of the hypophysis and of the meningeal membranes, with meningeal and ventricular hemorrhage. Experiments effected by Landaour (1931) on hens have shown that intoxication of the animal by thallium may exert an influence on its descendants.

Buschke and his pupils have likewise noted derangement of the growth of the bones and changes in the calcium metabolism. At the end of a certain time after the onset of the experimental poisoning a veil appears over the crystalline lens and even a form of cataract due to inflammatory change of the iris and intra-ocular hemorrhage, followed by troubles of the base of the eye and atrophy of the optic nerve. Other experts have noted also an extra-pyramidal hepatolenticular syndrome, and certain authorities a syndrome resembling the pseudo-sclerosis of Westphal-Strümpell, with an enlarged and painful liver (Insabato). This author thinks that acetate of thallium exerts an elective action on the anato-mo-functional extra-pyramidal complex, which accords with a case described as a choreiform syndrome due to thallium. Greving and Gagel (1929) found typical modifications of polyneuritis, degenerative changes in the Purkinje cells, in the medul-geniculate body and in nucleus of the oculomotor nerve. The vegetative nervous system does not appear to be affected.

The mechanism of the toxic action is not very clearly understood. It is thought to consist of a local effect and a nervous effect, or, again, of an endocrine action.

Absorption of the poison occurs by way of inhalation of dust liberated in the course of various operations either of manufacture or of manipulation of the product. There is a cumulative type of action, the product accumulating especially in the hair and on the skin.

Teleky considers that repeated doses are more likely to be harmful from a permanent point of view than one initial and single dose, as in the case of accidents connected with therapeutic treatment. From the industrial point of view, it must be remembered that the limit between harmless and dangerous doses is excessively small and is connected especially with individual susceptibility.

**STATISTICS**

Though the toxic action of thallium and its salts has been known for a long time, it is only recently that the importance of thallium from an industrial point of view has been adequately realised. Symptoms.
caused by it have perhaps been confused with lesions attributable to arsenic and lead. However that may be, available statistics are not numerous. In the annual report of the Prussian Factory Medical Inspectorate for 1927 Teleky drew attention to cases of intoxication by oxide and sulphate of thallium. These cases were also studied by Rube and Heindrik (1927) in two factories engaged in the manufacture of celiopaste. In 1928, Teleky reported that out of 14 workers in a factory for the manufacture of thallium or its salts, 3 only were free from effects. A case of thallium poisoning has also been reported as affecting an apprentice hairdresser.

PATHOLOGY

Industrial poisoning by thallium generally assumes the form of chronic poisoning with symptoms typical of the acute form. At the onset there is often interference with sleep and excitement (Teleky), which may pass unnoticed at times and the importance of which is only recognised later when further symptoms make their appearance. The first of these occur either a few weeks after commencement of work or at the end of several months (Teleky) and consist in pains located in the joints of the lower limbs, with weakness of the limbs, accompanied by muscular cramp, disappearance of the rotular reflex and that of the tendon of Achilles and sometimes even polyneuritis. At the end of a few months (Teleky) there is noted falling of the hair, gastric symptoms (profuse saliva, loss of appetite, vomiting, diarrhoea accompanied by loss of weight); nervous troubles (depression, fatigue, loss of consciousness, at times excitement, muscular spasms, attacks of hysterical laughter). As regards cardiac symptoms there are noted cyanosis, tachycardia, at times slowing down of the pulse, and in the renal system albuminuria develops at times fairly late (at the end of three months) and only disappears on cessation of work. Examination of the blood reveals characteristic lymphocytosis (over 40 and sometimes over 58 per cent.: Teleky), eosinophilia (7 per cent.: Buschke). These symptoms appear, moreover, very early, and have even been noted on one occasion to have affected a worker four days after commencement of work (Buschke). According to Testoni (1929) no punctate basophilia of the red corpuscles has been noted. At times symptoms of purpura have been noted.

Ocular lesions are very important, and may occur at an early stage: in a case described by Teleky, four months after appearance of the first symptoms.

Besides lesions of the iris and crystalline lens, there has been noted total central scotoma, bilateral, for red and green. In another case there was optic atrophy which did not improve. This constitutes the grave danger of thallium.

It should finally be stated that Egli has reported lesions connected with irritation of the nose and eyes due to liquid combinations of thallium.

The spectroscope enables detection of up to 2 mg. of thallium per litre in solution: a beautiful green ray is given.

HYGIENE

In 1920 the use of a product with a salts of thallium basis was recommended in the campaign against rodents. Tests (1925) were undertaken in the United States with a view to establishing whether salts of thallium might be effective against rodents and might be employed without danger to man. It was found that thallium is the most toxic and the most effective of all substances which can be used in an anti-rat campaign, since it is more active than strychnine and four times more active than arsenic.

As there is no warning sign accompanying its presence, use of the product should be reserved for those trained in its use.

Buschke, as well as Teleky (1931), has drawn attention to the necessity in those industries which utilise thallium and its salts for adopting adequate measures of prevention: general hygienic conditions; means of capturing and removing dusts which may be liberated; wearing of gloves or special working clothes. Periodical medical examination of the workers is also of importance (Teleky), and they should further be informed as to the risk to which they are exposed. Well-thought-out and well-applied prophylactic measures are quite sufficient. This is proved by the fact that Buschke and his collaborators, who worked for twenty-seven years with thallium, never suffered from any symptoms.

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Thorium

French and German:Thorium. — Italian and Spanish: Torio.

Thorium (symbol. Th.) is found in the natural state as a constituent of numerous salts: silicates, niobates, tantalates, titanates, phosphates—as, for example, Aeschynite (niobotitanate of cerium, of yttrium, etc., containing 23 per cent. of oxide of thorium), Ceylon thorianite containing up to 70-80 per cent. of oxide of thorium. In industry it is extracted from thorite, which is a hydrated silicate, and especially from monazite.

The latter consists to a great extent of phosphates of cerium, of didymium and of lanthanum, and contains mixtures of various quantities of thorium ore (3 to 10 per cent.). Deposits of monazite exist in the Transvaal and in Brazil. Monazite sands are produced in the United States.

In the pure state, thorium is a silver-blue metal, which melts at 1,700° C. and is ductile and malleable. It burns easily in air, becoming transformed into oxide, and is readily dissolved in hydrochloric acid and less so in sulphuric and hydrofluoric acids. Thorium is considered as the first element of one of the three families of radioactive substances. It emits α rays and an emanation (Toron) of very short duration. Like radium and actinium, it disintegrates into radioactive substances of less atomic weight, and gives rise to the following substances: mesothoriums 1 and 2; radionium, thorium X, Toron (emanations), thorium A, B, C, and omega, this latter being the isotope of lead.

Mesothorium is obtained from the residues got in extracting thorium from monazite by processes similar to those engaged in in the extraction of radium. A ton of monazite may give 2 to 5 mg. of mesothorium in a state of bromide.

The extraction of thorium in the state of a salt involves various complex operations. The ordinary concentrated monazite ore is ground down, treated with sulphuric acid in order to dissolve the phosphate of thorium and other metals it may contain (cerium, lanthanum, aluminium, iron). The sulphuric solution is neutralised by caustic alkalis, or ammonia or magnesium, by simple dilution with a given quantity of water, in order to cause a reprecipitation of the thorium in the state of a phosphate. The latter is purified by transformation into oxalate, which in its turn may be purified or transformed into hydroxide. In starting with thorite or thorianite, the series of operations terminates with hydroxide of thorium. The oxalate or hydroxide thus obtained are finally purified by transformation into the sulphate, which is then subjected to successive crystallisations. The sulphate is then transformed into a nitrate, which is the salt most commonly used, and from which may be obtained either pure thorium, prepared also by electrolysis of chloride of thorium or other salts of thorium: acetate, chloride, fluoride, sulphate, etc.

The preparation of powdered thorium was achieved in 1829 by Berzelius, who caused sodium or potassium to react on thorium chloride. Calcium is chiefly used for this purpose now. It is almost impossible to produce powdered thorium of a high grade by distillation of tetrachloride thereafter reduced by sodium, since the thorium becomes oxidised during the process of disintegration. The preparation of the chloride by distillation in chloroform, carbon tetrachloride or sulphur fumes has not met with success. Reduction of the tetrachloride by calcium has given better results.

Thorium is used in the manufacture of tungsten filaments for electric lamps. In the manufacture of the cathode for X-ray lamps; the acetate, and especially the nitrate, are used in the impregnation of incandescent mantles (see article "Incandescent Mantles"); in the manufacture of other salts and compounds of thorium; as a mordant in dyeing (nitrate). The chloride of thorium is utilised in the manufacture of pure thorium; the fluoride is used with other salts as an agglomerate for carbon electrodes during stages of electrolysis. The nitrate likewise enters into mixtures intended for the provision of luminous colours.

Mesothorium in the state of bromide or other preparations is chiefly used in obtaining luminous colours and varnishes which are phosphorescent in darkness (see article "Radium and Radioactive Substances").

The emanations of thorium are toxic. Animals (guinea pigs), after long ex-
posure to their action, die in about eight days. On post-mortem examination there is found hyperaemia of the liver, of the bone marrow and of the lungs, which show also infarcts here and there.

The influence of thorium X on the human body has been the object of study by Emile Weil and Lacassagne (1915), and by Averseng, Delas, Jaloustre and Maurin (1924), amongst workers handling thorium X, one of whom died of aplastic anaemia and another of myelogenous leucæmia. Another case of pernicious anaemia due to thorium X formed the subject of a communication presented by E. Weil, P. George and Laignel-Lavastine to the "Société de Médecine des Hôpitaux de Paris" (November 1926). There have also been reported cases of dermatitis, especially amongst workers engaged in the manufacture of incandescent mantles.

Friedlaender (1912) met with a case of generalised eczema, affecting a woman worker who had been engaged for two years on the operation of dipping incandescent mantles in a 30 per cent. solution of nitrate of thorium.

In 1913 he found in the case of another woman worker a form of eczema affecting the back of the hands, and especially of the right hand, with small patches on the forearm; the nails were sunken into the flesh as a result of swelling of the finger ends, and the skin of the palm of the hands showed ridges separated by deep cracks.

Lesser (1912) has also described a form of dermatitis due to mesothorium.

Measures of general hygiene and of cleanliness are requisite for the prevention of dermatitis and as a protection against troubles connected with radioactive properties. (For these, as likewise for legislation, see article "Radium and Radioactive Substances").

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Timber Industry


INDUSTRIAL OPERATIONS

In many countries forestry work is an industry of great importance, especially in regions with temperate climates, where very extensive forests exist.

In the first place the forest was made use of to supply wood for heating or building, or for agricultural or domestic implements which were made by hand. The trade developed when the sawing industry appeared, which used water falls and rapids for power, and later steam and electricity. Some time afterwards came the development of the wood pulp, cellulose, paper, artificial silk, etc., industries for which it has been possible to utilise trees too small to be sawn as timber and previously only fit to be used as fuel. Forestry is essentially of a seasonal nature and has often to be carried on far from centres of habitation, and, year in year out, in different parts of the forest. The work includes first felling the trees, clearing and lopping, then felling, and transport in the forester's district. The sale of timber for fuel is also carried out chiefly in the forest at the place where the trees are felled. The timber is piled up to dry and then, when dried, is transported. Sawing into baulks and planks is also partly done in the forests by portable motors which use traction engines or motors for power. This method of working seems to be making great progress.

In addition to the felling, afforestation also takes place in forestry districts: the improvement of the forest soil by drainage and the appropriation of ground. Numbers of trees are then sown and planted. This work, as regards hygienic conditions and comparing the actual work, can be placed on a par with agricultural employment, especially with that of breaking up land for tillage.

The felling of trees is still often done by bill-hook, hachet and hand saw. But, as this work is slow and costly and necessitates a considerable amount of manual labour, inventors in all countries have been stimulated to devise practical cutting machines.

There are several quite distinct operations: clearing or removal of undergrowth, which consists in the removal of thickets, straggling shoots and thorn bushes; cutting small timber and large trees; topping off branches from trunks; and cutting them up into pieces. Each of these operations necessitates a special machine.

Cutting by burning with a metal wire, heated to a high temperature, has been tried, and also this method combined with movement of the wire. But these attempts have always failed, and cutting by actual removal of material seems to present the best solution of the problem. Felling on this principle may be carried out by saws with to-and-fro or circular movements; by hand saws;
by axes or mechanical cutters; by wire or chain ecraseurs; by drills making holes close together; or by the undermining action of ecraseurs of different shapes.

This work is done chiefly in the autumn and in winter before the rising of the sap. In cutting the face of the trunk is removed on the side towards which the tree is to fall. Then sawing is proceeded with at the same height on the other side. This operation is often done by two men working together. Often, for instance, if the weather is stormy, the tree may fall differently to what has been intended, and the workmen are liable to be injured, sometimes fatally, by the trunk or branches. During trimming and removal of the bark, the axe, especially during winter when the tree is frozen, may easily glance off and wound the worker or tear the clothes. These accidents are common and can only be avoided by using good tools and exercising care. The trees are often placed in such a manner that it is necessary to slide and roll them down steep inclines with a view to their further transport. The workmen are then exposed to contusions and wounds of various kinds.

In forest districts the ground is often rough: blocks of stone, stony ground, beds of streams, marshy ground, all these make transport impossible in the hot season. When, on the other hand, the ground is frozen and the uneven parts are covered by snow, it is possible to use horses as draught animals, which are almost everywhere indispensable in the forest. Only horses resistant to fatigue and cold and specially suited for the work can be employed. In the most northern parts of Scandinavia refrigeration is necessary.

Logs and wood fuel are conveyed for long distances over ice and snow.

In countries where there may be no snow it is possible to arrange for transport by rail or lorries, as in Canada and the United States of America.

In Norway, logs are often drawn in the following way: a hole is made at the thin end of the log and tackle is attached thereto. The position of the log is sometimes such that the tackle must be attached to the thick end. When horses are used for traction, if the tree gets jammed between stumps or large rocks, it may fly back when set free, and so hit and break the leg of the driver if he happens to be so placed that he can be struck. If the tackle is attached to the thin end of the tree, this may also cause a recoil, if the tackle or the hole in the timber give way. In this way the driver may sustain a fracture of the tibia or fibula, an accident which is typical of this kind of work (Th. Ansteensen). The tackle may also be fastened to a hook screwed into the tree. The logs are collected in a pile near to the forest tracks which are most suitable for transport. Later the transport is carried out on sledges specially constructed. The logs are transported to centres where they are all collected and from thence by road, rail, or river (floating) — this last being the most economical means of transport. When flotation is made use of, the timber must be sufficiently dry; otherwise it may sink when thrown into the water. That is why timber is deposited in a dry place and is never thrown during the autumn or winter into open water, nor put in a place where it may be covered with ice. It is only in early spring that it can be floated. The ice breaks up about the time of the melting of the snow, even the rivulets of forest districts contain sufficient water to float the timber to the large water courses and lakes, where it is collected by barriers formed by poles chained together, or gathered together as rafts which are then towed. Logs which have not been drawn over the ice are thrown down river banks into the water when the snow melts.

During flotation some logs become caught and remain fast, thus forming an obstacle which stops the logs floating behind. Thus in a short time a considerable obstruction may be caused. The lumbermen, furnished with long boat-hooks, have then to try to clear the entanglement. If the freeing takes place suddenly and unexpectedly the lumbermen are often drawn with the logs into the rapids; it is quite common for drowning accidents to occur in this way. Steel cables are often used in flotation work on rivers, and these may become worn and easily cause abrasions of the palm of the workers' hands. Cases of pyaemia have been reported as the result of these accidents.

Another wood industry which is very often set up in the depths of the forest is that of carbonising or distilling wood.

The plant and equipment vary according to the aim and object of the undertaking, whether for producing from the wood gas, charcoal, or volatile condensable products.

Such a factory always possesses a timber yard for the wood to be used during the year; the wood should be well air-dried, and, before it is used, at least twelve to eighteen months should elapse from the time of cutting. The yard may or may not have a saw-mill attached. The wood when piled up is
loaded on trucks or rails, which carry it to the carbonisation. Sometimes the transport is carried out by aerial transporters on cables or rails or by transporter elevators with an endless rope.

Artificial drying is carried out in horizontal tunnel-ovens heated by waste gases from retort furnaces. The trucks enter the retorts, from which they come out after carbonisation and then, after a pause in extinguishers, pass again to the timber yard after the charcoal has been emptied out.

The driers, retorts, and extinguishers are generally arranged in series.

The other buildings of the factory may be arranged in various ways: the removal of tar, the saturation, the de-alcoholisation of pyroligneous acid, and the preparation of acetic of lime and of soda take place in workshops in the immediate proximity of the retort building. As a measure of safety rectification of residues and treatment of tar are carried out separately.

Carbonisation can be carried out:

(a) In the forest, by the classical pile of the charcoal burner, still frequently used at the present time. This method has naturally been modified and modern mobile apparatus enables volatile products to be recovered.

(b) By furnaces called kilns composed of a large mass of masonry, which is, however, of less efficiency than other apparatus.

(c) By vertical retorts. They constitute the classic model used in Central Europe; although it presents some disadvantages, it still has its supporters.

(d) By horizontal retorts with trucks; in use in the U.S.A. and also adopted in Europe: this is the most advantageous solution for a big concern. There are many models of these retorts. They are generally of sheet steel, with pipes at the top for the escape of gas, and of cylindrical or rectangular form. They hold a train of trucks.

(e) By other types of apparatus which resemble more or less the types described, but present special features.

(f) By apparatus for the carbonisation of waste wood: a complex technical problem which has led to the production of numerous plants which are employed according to the bulk of the waste, in order to obtain condensable volatile products, or briquettes of charcoal.

(g) By gazogenes burning wood for the gasification of wood.

If wood is heated progressively in a retort connected with a cooling apparatus, it is found that at about 100° C. the water contained in the wood distils over. If a resinous wood is being treated it will be seen from the start that there is a slight layer of spirit on the condensed water. At about 150° C. this water takes a deep coloration and undergoes an acid reaction, whilst the wood begins to go brown. At about 250° C. the wood is in full pyrogenetic decomposition; this decomposition increases further towards 270° C.; it continues even if the heating of the retort ceases. The liquid obtained separates after standing into a lower layer of intensely black tar and an upper aqueous layer of a deep red colour which is known under the name of "pyroligneous juice". The gases which come off in clouds from the cooling apparatus consist chiefly of carbonic acid and carbon monoxide.

Above 300° the distillation proceeds more slowly; it is practically complete at about 400° and then only small quantities of gas and condensable vapours are given off. A residue of black and shining wood charcoal is found in the retort.

To sum up, the distillation of wood gives the four following products: wood charcoal, crude pyroligneous juice, wood tar, and gas. The proportion of these different products varies according to the kind of wood treated and the method employed in distillation (see diagram, fig. 154).

Pyroligneous juices consist of an aqueous solution of organic products of which the principal are acetic acid (3-10 per cent.), methyl alcohol (1.5-3 per cent.), acetone (0.1-0.2 per cent.). In addition to these products are found the homologues of acetic acid, allylic alcohol, furfurol, acetic aldehyde, methylethylketone, etc., and of dissolved tars as well.

The combination of the acid products extracted from this juice forms what is known commercially as pyroligneous acid: the combination formed by the other volatile products, among which methyl alcohol and acetone predominate, forms what is known as methylene. The tars are very complex products; those from non-resinous woods contain "caramels" more or less soluble in water, various neutral products, phenol products such as creosote, among which guiacol is the chief. In the case of resinous woods the oils of resin abound according as the wood contains more or less resin: these products are over and above the normal tars of the wood.
Industrially the distillation of hard wood gives a result approximately as follows: charcoal, 23-30 per cent.; gas, 18-25 per cent.; tar, 4-6 per cent.; pyroligneous acid, 4-5 per cent.; methylene, 1.2-1.5 per cent.

Integral distillation is carried on in retorts heated by an external furnace. In place of small mobile retorts, large fixed horizontal retorts have now been substituted, the charging and discharging of which are done from metal trucks which are filled with wood outside the furnace and are passed on complete trains into the retort house, whilst a train containing glowing charcoal from the preceding charge is rapidly drawn out from the retorts and removed to an extinguishing chamber.

In modern installations distillation of wood is done indirectly by the circulation of hot gas previously obtained from the gases of distillation as they leave the cooling apparatus, and heated by being passed over radiators.

For the distillation of such things as sawdust, shavings, and fruit stones, cylindrical rotary ovens are used.

The condensing apparatus placed at the exit of the retort house generally includes: a tar remover, which retains the tars without condensing the pyroligneous juice; a cooler for condensing the pyroligneous juice in bulk; and a "scrubber" to catch the vapours of methylene and acetic acid which are carried over in the gas from the distillation. The gases coming from this apparatus are combustible; they are passed under the furnaces of the retorts.

Among the products of distillation, charcoal alone, after rapid screening, is ready for immediate sale. As regards the rest the liquid products require first to be subjected to various processes.

The decanted pyroligneous juice contains acids, pyroligneous acid, methylene, and tars. These last, which are non-volatile, are separated by distillation; the pyroligneous acid is separated from methylene by making the mixed vapours pass to and fro through boiling alkaline solution (milk of lime). These processes are carried out by what is called the triple boiler method (méthode des trois chaudières). The pyrolignite of lime is evaporated and eventually gives a viscid mass which is dried to obtain the grey pyrolignite of lime, a deliquescent salt with 80 per cent. of pyrolignite of lime, which is generally sold in that form.

The methylene derived from the methylenic residue (phlegma) is recovered at 90° C. and is also saleable in this form.

Tars from resinous woods are generally directly saleable after a simple dehydration; tars from non-resinous woods are often used as fuel, but creosote can be obtained from them by treating the fractions of tar collected at about 200° C. with soda, which dissolves the phenols, which in their turn are precipitated by acids. The tars of resinous woods are used in rather interesting ways for the impregnation of marine cordage and fabrics. Purified oils from pine wood are used as inexpensive solvents. Tars from non-resinous woods give, besides creosote, guiacol, and their derivatives, some solvents, or low-priced burning oils (carburants).

Modern processes for the preservation of wood may be classed in two categories — in one process products with a tar base are used, and in the other process saline solutions.

In the first category the best process is that with a base of tar oil. A modification consists of a bath of heavy oil of tar at 140° C. followed after three
of or four hours by a bath of the same oil, but at normal temperature; and finished by a bath of chloride of zinc.

In the second category are classed processes using zinc or sulphate of copper, which, however, are being replaced more and more by processes of kyanisation. By this process, invented in 1838 by Kyan, a solution of bichloride of mercury and fluoride of sodium is used to impregnate the dry wood. The timber was steeped for twelve days in a 2-3 per cent. solution of bichloride. This solution is nowadays replaced by a mixture of fluoride of sodium and organic compounds (10 to 20 per cent.) generally of dinitrophenylamine, known under the name of "basilite".

It has also been found that bichromate of copper brushed or sprayed on is very efficacious for the preservation of timber, whether soft or hard and whether exposed to the weather or not. This solution is prepared by mixing warm solutions of potassium or sodium bichromate and copper sulphate.

The problem is a very important one in connection with the preservation of timber used for sleepers and telegraph posts.

It is very difficult to reach the heart (the central part) of timber with injections; hence timber which shows sap wood (young exterior part) and heart cannot be made completely aseptic. This is the reason why the injection of such antiseptic fluids as creosote and sulphate of copper is carried out under pressure in large watertight cylinders containing stacks of prepared sleepers. In order to obtain a better result a jet of steam is driven into the cylinders so as to remove the air: heating the timber opens up its pores; a vacuum is then created and it is only when this has occurred that the antiseptic solution is put in the cylinder. In order to obviate certain disadvantages timber is nowadays submitted to a "rapid artificial ageing" by which it is sterilised by eliminating air from the pores. This operation is carried out in an oven in which the timber is submitted to the action of a current of vapour from an organic material possessing a constant boiling point.

Very expensive and rare woods, either on account of the selling price or of the costs of transport, are not worked as solid beams, but are cut into very thin sheets for covering furniture made of common wood. This is the industry of veneering wood.

A slicing machine cuts a trunk into a sheet with a thickness of about two to three-tenths of a millimetre, which rolls off in one piece like a roll of photographic film. The machine is actuated by very exact clockwork movement, which has to be adjusted most accurately.

The thin sheets are next submitted to slow drying and then cut up and prepared for use.

It is interesting to consider the importance of the nature and composition of the glues used in veneer work, for they must ensure a close and definite solder between the sheet of veneer and its support.

In modern carpentry wood is worked by a large number of machine tools, although these have not been brought to the same state of perfection as the machine tools used for working iron. It will suffice, however, to mention here: to-and-fro saws; saws for carrying and cutting wood in pieces; machines for splitting, slicing, smoothing, planing, scooping out, drilling, morticing, carving, and copying; machines for making grooves, mouldings, discs, wheels, etc. Wood for brushes, casks, wheels of vehicles, wooden clogs, shoe lasts, etc.

**Pathology**

For forest workers the forest is their factory. The work is done in open air, and from this point of view under the best of hygienic conditions. It is animated, but is hard and tiring, for it is generally done in the cold season and in regions where the temperature may be very low. Frostbite, which naturally makes its attack on such prominent parts of the body as the ears, nose, cheeks, fingers, and toes, is very common.

Forest labour is often associated with accidents; sprains, contusions and wounds from blows are of course the most frequent; next come fractures of the legs and arms. These accidents occur while hewing, topping, and barking trees, when the workmen throw down, load, drag, or unload the timber on rough ground. Then again, frozen ground increases the risks of these accidents. In Norway where insurance against accidents is compulsory, the premium for work in the forests is average.

Such rheumatic affections as lumbago and sciatica are common among forest workers. So also is dyspepsia, while cases of phthisis are not uncommon.

As has already been mentioned, forest work is often carried out at great distances from inhabited centres. The housing provided for the workers in the forests is usually unsatisfactory. They have (although in some countries this happily is only a memory of the past) to be content with small damp huts,
badly constructed, exposed to draughts, consisting of a single room, in which the workmen sleep, prepare their food, eat, and live.

In the district of Frankfort some cases of poisoning by mercury were reported in 1921, as well as in 1922 in Saxony, among workmen employed on the impregnation of timber with bichloride solution.

In Austria workmen employed on the impregnation of timber with chloride of zinc (1920-1922) were troubled by the irritating gases given off during the operation. Into the tanks in which the timber was stacked zinc slag was placed and over this dilute hydrochloric acid was poured. The reaction was violent and gave rise to a great ebullition of irritant gas, which affected workmen even at a distance of 100 metres from the tank.

Some similar cases have been reported in the United States by Carey, McCord, and Kilker.

According to Sekouilitch (1925), persons employed on wood work experience, due to the action of dust, frequent acute attacks of respiratory disease. The lesions appear gradually to pass into chronic forms and even into malignant tumours (cancer in particular) which are situated at the level of the junction of the lungs and stomach. The products of distilling wood, consisting of tannins and essences, set up chronic irritation, so that, as with pitch and tar, the derivatives of wood manifest a carcinogenic action, which must be borne in mind.

According to the statistics of the Health Insurance Office of Leipzig, wood workers present a comparative sickness rate as follows:

<table>
<thead>
<tr>
<th>Disease Category</th>
<th>Total</th>
<th>Pulmonary tuberculosi</th>
<th>Nervous diseases</th>
<th>Respiratory diseases</th>
<th>Circulatory diseases</th>
<th>Digestive diseases</th>
<th>Diseases of the skin</th>
<th>Diseases of the excretory apparatus</th>
<th>External lesions</th>
<th>Accident</th>
<th>Classified according to danger from poisoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>The whole group</td>
<td>1.1</td>
<td>1.1</td>
<td>1.0</td>
<td>1.1</td>
<td>0.9</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.0</td>
<td>1.1</td>
<td>I</td>
</tr>
<tr>
<td>Picture-frame makers</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.2</td>
<td>I</td>
</tr>
<tr>
<td>Coopers</td>
<td>1.8</td>
<td>0.9</td>
<td>0.9</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.6</td>
<td>I</td>
</tr>
<tr>
<td>Wheelwrights</td>
<td>1.0</td>
<td>0.9</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>I</td>
</tr>
<tr>
<td>Turners</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.0</td>
<td>1.0</td>
<td>I</td>
</tr>
<tr>
<td>Wood workers (factory)</td>
<td>1.1</td>
<td>0.9</td>
<td>1.2</td>
<td>1.4</td>
<td>1.0</td>
<td>1.3</td>
<td>1.2</td>
<td>1.2</td>
<td>2.0</td>
<td>2.5</td>
<td>I</td>
</tr>
<tr>
<td>Basket makers</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.9</td>
<td>0.6</td>
<td>II</td>
</tr>
<tr>
<td>Sawyers, Choppers</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.9</td>
<td>0.9</td>
<td>IV</td>
</tr>
<tr>
<td>Carpenters</td>
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<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.9</td>
<td>0.9</td>
<td>IV</td>
</tr>
<tr>
<td>Wood polishers</td>
<td>1.6</td>
<td>1.4</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>II</td>
</tr>
</tbody>
</table>

The death-rate, which for the whole group does not exceed that for all insured members, exhibits exceptions for the groups of coopers and of basket makers. For carpenters of the United States a death rate is given of 231 per 100,000 living. For 7,883 deaths, 10.1 per cent. were from tuberculosis, 7.1 from pneumonia, 2 from other respiratory diseases, 14.4 from circulatory diseases, and 2.7 from diseases of the digestive organs.

Among the diseases of the skin noted amongst carpenters should be mentioned those caused by the liquids used, e.g. solutions of potash or caustic soda, liquids for polishing, usually with a base of methyl alcohol or of denatured alcohol, and the different lacquers. Cases of urticaria, erythema or eczema caused by poisonous or exotic woods (see that article) are common and occur on the face, the neck, the hands, etc. Cases of bursitis of the wrist, elbow, and even of the knee among men who lay parquet flooring are numerous. After incision it is not uncommon to find that the cicatrix is painful and that it causes incapacity for work. Whitlows and phlegmons are frequent. Out of 5,341 cases observed at the Bureau for German Carpenters, 518, or 9.7 per cent., were cases of cellulitis.

The finger-nails are often coloured by the different polishing liquids or by the dyes or mordants used for the wood. The dust of wood or of substances used, and mineral particles may become deposited in the skin and thus form stigmata characteristic of these workers. Occupational callousities are situated on the pulp of the thumb and index finger of the right hand and often on the central part of the palm, where a bursitis may also be found. Among carpenters these marks are found on the thenar region.

Among cases of occupational infection, the case of a carpenter employed in repairing a manger infected by a diseased horse is interesting. It appears that the workman developed sporotrichosis.

Some cases of lead poisoning have
be noted among carpenters who use lead colours such as white lead and chromate of lead, or coatings with a base of prot oxide of lead in oil of turpentine and spirit in order to give wood a dull appearance.

Schuckardt and Wormhing found among workmen engaged in the manufacture of rulers, coated with chromate of lead, a large number of cases of poisoning with irritation of the throat; this occurrence has also been confirmed by the statistics of the Sickness Insurance Office of Leipzig.

There should not be omitted cases of irritation of the eyes (blepharitis and conjunctivitis) due to dust or to vapours from the liquids used and especially to methyl or denatured alcohol.

A case of catarrhal blepharo-conjunctivitis from sensitiveness to "green wood" has been reported by Lagrange and Pesme (1922). Traumatic lesions from fragments of wood that fly off from the machines are fairly common.

Among carpenters cases of crepitant teno-synovitis have also been noticed produced by planing; among the men employed in planing, calllosities are found on the thumb and index finger.

Wounds of the hands, fingers, and forearms are frequent, due to such wood-working machines as drills, planes, circular and band saws; they are quite characteristic and often lead to amputation. The Vienna Bureau noted among compensation cases 16.4 per cent. of wounds. Burns occur chiefly on the back of the hand.

Among effects on the locomotor system are reported cases of flat feet; deformity of the knee in carpenters, but less marked than among bakers; deviation of the spinal column, an extra height of the right shoulder which is characteristic of carpenters who plane by pushing with the right hand and pressing with the left. According to Sternberg the chest of carpenters has a special shape: it is flattened with scapula alata.

The joints are frequently affected and articular rheumatism is noted by different authors as quite a common cause of ill-health.

Comparatively common are troubles of the circulatory system and in particular of the vessels, e.g. varicose veins, especially of the left leg among carpenters. The endocarditis frequently found among wood workers is explained by the rheumatism and inflamed tonsils noticed among these workers.

Numerous cases of bronchitis are reported due to wood dusts which, according to certain authors, predispose to tuberculosis. The experts blame the introduction of such machines as circular saws and drills for causing increased amounts of dust. Out of 100 carpenters living, 13.37 were affected with tuberculosis, whilst among other wood workers there were only 10.06 and the total for all other occupied males was 3.07 (Koelsch).

Out of 5,341 cases of sickness registered by the Office of Carpenters at Vienna, which included 10,071 members, 1,056, or 28.1 per cent., were cases of tuberculosis or other respiratory diseases (Sternberg).

There may be mentioned here the troubles due to the condition of anaphylaxis (asthma caused by the inhalation of dust).

Gastric troubles have been attributed to the bad habit of drinking the liquids used for polishing (see article "Occupational Diseases: Digestive System").

Numerous cases of neurasthenia have also been noted among carpenters which may be attributed to overfatigue.

**HYGIENE**

The conditions of work and lodging during work in the forests are such that the employment of children and young persons should not be approved. The work is too hard for persons whose physical development, not being complete, would certainly be affected by the strain, causing acute hypertrophy of the heart as well as serious chronic sequelae. The feeding, which is monotonous and unsatisfactory during the stay in the forest, predisposes to diseases of the digestion and to diseases of the blood and nutrition. There are then reasons for prohibiting the employment of young persons at this work and for improving the living conditions of the workers as regards both accommodation and food.

Forest labour is dependent on rain, snow, and fine weather. Hence there are certain difficulties in applying definite rules regarding hours of work in this industry; on the other hand, attention can be devoted to seeing that the auxiliary machines are properly erected and protected and that the tools used are adequate. For housing and accommodation in general the same minimum hygienic conditions should be required as are laid down for builders and agricultural workers (see article "Social Welfare").

As accidents during work in the forest are very common, and as doctors are only to be found at some distance away, provision should be made at the places of work for suitable first-aid appliances in sufficient quantity (see article "First Aid").
A wood-working factory equipped with machinery, if suitably arranged, includes today, besides the machinery, a complete system of ducts intended for trapping the dust and shavings, produced in large quantities by tools revolving at great speed, and for removing these outside. One part of the installation is intended specially to trap the dust. The exhaust openings are placed as near as possible to the tool in use. But it is important to avoid as far as possible setting up a draught which might be somewhat bad for a workman obliged to work in one corner of the workshop without moving about. This disadvantage is avoided by not placing the openings of the exhaust apparatus too near the tools, but at different carefully-chosen points in the workshop, e.g. on the floor, in corners, half-way up or near the ceiling; the atmosphere is then, however, less effectually cleared of dust.

Dust is then, however, less effectually cleared of dust. The exhaust openings are placed as near as possible to the tool in use. But it is important to avoid as far as possible setting up a draught which might be somewhat bad for a workman obliged to work in one corner of the workshop without moving about. This disadvantage is avoided by not placing the openings of the exhaust apparatus too near the tools, but at different carefully-chosen points in the workshop, e.g. on the floor, in corners, half-way up or near the ceiling; the atmosphere is then, however, less effectually cleared of dust.

Different plant is provided for the automatic removal of shavings, sawdust and small debris, which fall during work. The openings of the suction apparatus are in this case placed near the tool.

All measures must be adopted to ensure adequate provision necessary for preventing fires and dust explosion (see article "Dust").

**Legislation**

The employment of children and young persons is regulated in different countries by laws concerning the work of children, especially when concerned with dangerous or heavy work, or that done by the aid of power-driven machinery. In Belgium children under sixteen years are excluded from the grinding of wood used for colouring (mills); in Canada (Quebec) they are excluded, as well as girls under eighteen years, from the mechanical sand-papering of wood. In Holland the employment of young persons is restricted by conditions laid down by the Act of 1899 when the work is done by means of machines and mechanical tools (section 25 (1)) and in certain processes such as drilling wood, and carving and engraving on wood, when the work causes dust, unless the means of avoiding risks to health laid down by legislation are adopted. Without entering into details, it will suffice to mention here and emphasise the importance of safety measures for the prevention of accidents either during work in the forest, or in the wood-working workshops, and saw mills.

Special legislation concerning wood working has been laid down in the following countries:

**Australia (West):** Regulations of 24 December 1926 on timber yards where wood is cut up.

**Denmark:** A very detailed Ministerial Decree dealing with wood works, dated 21 May 1908.

**Finland:** Resolution of 30 December 1924 concerning saw mills and timber yards.

**Germany:** Measures of hygiene and safety drawn up by the authorities of Berlin, 31 March 1914.

**Great Britain:** Order of 8 November 1918 on the provisions of ambulance and first-aid appliances in saw mills and factories making wooden articles, and Regulations of 1922 on machines for wood working.

**Canada:** The Provincial Bureau of Hygiene of Manitoba laid down in 1925 a series of regulations for the sanitary control of timber-yards (hewing, etc.)

**Great Britain:** The Statutory Order Rules of 8 November 1918, No. 1489, lay down measures concerning first aid in the wood industry.

**Latvia:** The Act relating to the floating of timber is dated 29 December 1926.

**Norway:** The Act relating to the insurance against accidents of industrial workers, etc. (Lov om ulykker i forbindelse med industriarbeidere, m. v. of 13 August 1915, with the additional Acts of 26 July 1918, 26 June 1920, and 17 July 1925), as well as that relating to insurance against sickness (Lov om sykeforskring) of 6 August 1915, modified by the Acts of 15 June 1917, 23 July 1918, 10 December 1920, 16 February 1923, 17 July 1925) extend to forest workers the advantages laid down for other workers; there is also the Act relating to the housing accommodation of men and horses during work in the forests and flotation (Lov om husvær for folks og hester under skogarbeide og flotting), dated 30 July 1915. In accordance with this Act, the local authorities have power to lay down regulations for the construction and management of suitable accommodation for men and horses.

As an example the arrangements approved by the canton of Røken are given below:

1. Any building used for the accommodation of workmen employed upon forestry or flotation work during the period from 1 October to 15 May shall be:
   (a) erected on a dry site where water is easily obtainable;
   (b) placed on stone foundations or furnished on the outside with a bank of turf or earth round the walls;
   (c) provided with solid walls with good joints and a good watertight roof, with good doors and well-fitting windows, with shelves, with beds placed at least 40 cm. from the floor, with a heating stove either self contained or connected with a chimney, with boxes containing first-aid appliances and a cupboard for keeping food; and
   (d) provided with adequate means of ventilation.

2. Any building or shed used as a stable during the transport of timber during...
the period from 1 October to 15 May shall be
(a) erected on a dry site;
(b) placed on stone foundations or furnished on the outside with a bank of turf or earth around the walls; and
(c) provided with solid walls with good joints and a good watertight roof, with good doors and well-fitting windows and stalls with a wooden floor; the stalls should have a minimum width of 1.95 m. and a length of 2.05 m. including the manger.

3. In accordance with the orders of the Health Council, any forest owner is required to proceed with the erection of the buildings referred to in sections 1 and 2 before commencing felling timber for sale or for industrial production, or before the expiration of a period fixed by the Health Council and dated from the commencement of felling.

4. A copy of these Regulations must be put up in a conspicuous place in each of the living quarters concerned under sections 1 and 2.

Russia: Ordinance No. 144/733 of the People's Commissariat of Labour, dated 12 April 1923, deals with conditions of work in the open air during the cold season; Regulations of 10 May 1922 are concerned with measures of safety in enterprises working wood by mechanical means.

Sweden: The Act relating to insurance against accidents during work (Lag om försäkring för olycksfald i arbete), dated 17 June 1916, with additional Acts, extends also to forest workers.

Switzerland: Instructions prepared by the federal inspectors of labour for workmen employed in the wood industry.

Uruguay: Decree of 26 February 1927 on the working of wood by machinery.

Accident insurance covers forest workers in some countries (British Columbia, Estonia, Finland, France, Germany, Italy) either by special legislation, or by regulations laid down for the industry.

In other countries, the workmen are insured against accidents as soon as they work on premises or in any place where mechanical power is employed, even if the number of the workmen employed is lower than that laid down as requiring an employer to take out an insurance policy (Argentina, Austria, Brazil, Chile, Czechoslovakia, Norway, Rumania, Spain, etc.).

Mercurialism among workmen employed in the kyanisation of wood is compulsorily notifiable as soon as there is inflammation of the joints and of the subcutaneous cellular tissue among carpenters in Holland and cases of diseases of the skin (eczema and dermatitis) among ebony workers. (See also articles "Dust", "Liquids", "Skin Diseases", etc.).

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Dr. O. Lorang

Tin


Tin (symbol Sn.; atomic weight 119) is a metalloid which is not found in nature in the free state. The mineral most in use for obtaining it is carsterite (SnO2), which is found especially in Great Britain, Saxony, Bohemia, Spain, Chile, Mexico, India and Malacca. In the deposits carsterite is present itself in three forms: in veins mixed with pyrites and mispickel (rock tin); mixed with sand (stream tin); and in fibrous concretions (wood tin).

Metallic tin, white and of a brilliancy recalling silver, possesses a characteristic taste and smell. It is the most fusible of all metals (melting between 228 and 232° C.). It boils at about 2170°, but before that it gives off reddish white fumes. Rather tenacious and very malleable it can be reduced to very fine leaves without hammering.

Tin changes very little in dry or humid air—hence its use in tinning (for this see below); when cast into moulds it becomes coated with a fine scale composed of the oxide and dioxide of tin—tin dross.

Tin is readily attacked by nitric and hydrochloric acid, but sulphuric acid has no obnoxious action. Boiled with potash, it is converted into potassium stannite.

INDUSTRIAL PROCESSES

The amount of mineral is first increased by sorting, crushing and wash-
The shaft furnace is generally constructed of granite; at its base a pipe communicates with a blower. The combustion of the coke is incomplete and it is the carbon monoxide which effects the reduction. The ashes are retained in the first outflow basin — the first crucible — and the tin is next run into a second crucible and finally into moulds. The ashes are recovered and melted in a smaller furnace with ashes from the furnace grate. The reducing action of the iron permits of further recovery of tin.

A reverberatory furnace is that most frequently used. It has a sloping floor — the molten tin can thus flow outside into a crucible. A little lime or fluor spar is added in order to assist the melting of the gangue and it is rabbled to remove the ashes.

**Refining**

The German method depends on the passage of the molten tin over a steel plate bearing red-hot charcoal; the less fusible metals remain with the charcoal and the tin flows into the moulds. In Great Britain the tin is fused, the lightest scale is removed and green boughs are plunged into the molten mass. The gases developed bring to the surface all the impurities which are removed by skimming. This process is called "poling".

**Recovery of the Tin from Cans, etc.**

The waste materials most used are old tin cans. Many processes exist for the recovery of tin from them, of which the commonest are:

1. Treatment with chlorine in the cold state; then only the tin is attacked and is converted into the liquid tetrachloride which is easily separated.

2. By means of a soda solution containing a little plumbite or sodium nitrate: a current of air is passed until all the tin is dissolved and then electrolysis is practised. Stannate of soda is formed which is converted into stannic acid by means of carbon dioxide. The stannic acid is then reduced by charcoal.

3. The scrap is immersed in a solution of copper sulphate. The copper is precipitated in the metallic state and the tin dissolved with a part of the iron.

In the United States the increasing price of tin makes recovery more and more important, especially since the
TIN

use of de-tinned scrap finds a readier market than does the tinned.

In the Goldschmidt process chlorine is introduced under pressure in the detinning chamber. In the Van Scutz process a dry mixture of chlorine and some other gas, e.g. dry air, is made to pass over the mass of scrap. This is the more rapid process. The process is simpler and maintenance very easy.

In the Aker process liquid chlorine continuously liberating chlorine gas is used as the detinning agent. Another process employs a mixture of stannic chloride and chlorine in a closed vat.

The chlorine processes would appear to have the advantage over electrolytical methods in allowing of the treatment of large quantities at one and the same time and they reduce handling of the scrap to a great extent.

**Compounds of Tin**

The chlorides are the most important stannous chloride (SnCl$_2$), anhydrous stannic chloride (SnCl$_4$), and hydrated stannic chloride (SnCl$_4$·5H$_2$O).

Stannous chloride (salt of tin, tin crystals, muriate of tin) is prepared by the action on granulated tin of concentrated hydrochloric acid, containing sometimes a little nitric acid, in stoneware or copper vessels. Heating is effected by a water bath; the vessels require to be covered and the gases drawn off. When the action is completed, decantation follows and the liquid is concentrated in leaden crystallising vats.

Stannous chloride can also be prepared by using gaseous hydrochloric acid. The manufacture of chloride of tin leads to the formation of a certain quantity of arsenic chloride.

Stannous chloride is a crystalline substance with an astringent taste. When heated it melts at 40°C., at which temperature it loses its water of crystallisation. It becomes yellow on contact with air through absorption of oxygen and water vapour. In solution it is an energetic producing agent. In dyeing it is used as a mordant to freshen colours, and in calico printing as a discharge.

Anhydrous stannic chloride (perchloride of tin, tin tetrachloride, smoking liquor of Lebavius) is prepared by treating tin when hot with chlorine in special retorts. Several other methods are in use for its preparation, among which there should be mentioned, as particularly dangerous, that of causing mercury dichloride in powder form to act on an amalgam of mercury and tin; anhydrous stannic chloride is a yellowish liquid boiling at 20°C. and solidifying at —30°C.

The hydrated stannic chloride (butter of tin) is prepared in several ways: (1) by dissolving tin dioxide in hydrochloric acid; (2) hydration of anhydrous chloride with water; (3) treatment by chlorine of a concentrated solution of a tin salt; (4) mixture of salt of tin and hydrochloric acid, and then addition gradually of nitric acid (escape of nitrous fumes).

Hydrated stannic acid is a very deliquescent white mass. It is very soluble in water. It is used in dyeing as a mordant, for charging silk, and in the manufacture of tinned articles. The tin compositions known under the names of "oxychloride of tin", etc., are mixtures of stannous and stannic chlorides and oxychloride of tin.

Tin sulphide or mosaic gold is used for imitation gilding of wood and in calico printing.

It is obtained by a wet and dry method. The latter, although not so simple, gives the better results. The operation is done over a sand bath (good localised ventilation is needed to remove the very poisonous fumes).

Tin shavings are heated with mercury over a sand bath; an amalgam is obtained which solidifies on cooling. A mixture of sulphur and sal ammoniac, prepared beforehand, is added to the pulverised amalgams. Heat is gently applied until no more fumes come off; then the temperature is raised to red heat, after which it is cooled.

Mosaic gold occurs in beautiful golden yellow crystals and those of the best quality are found in the upper part of the tubes.

A scale of tints varying from clear yellow to bright orange can be obtained by modifying the composition of the mixings or by boiling.

**Uses**

Metallic tin is used for making vessels and utensils of every description, beer pipes, etc. Reduced to foil it serves for the packing of merchandise (chocolate, cheese). Tin foil is made by hammering or rolling, or again by melting it in such a way that the molten metal is made to flow on to a revolving wooden cylinder covered with felt. Mention should be made of the fact that certain foil called tin foil, which serves to wrap up tobacco and tea, contains up to 90 per cent. of lead. This is not without danger to the consumer. Tin foil, however, is now largely replaced by aluminium foil. The tinning of glass — a dangerous process because of the use of mercury, is no longer practised; all looking-glasses are to-day made by silvering. Tin has replaced lead, as the material for the bed, in hand file making.

Tin forms many alloys, of which the commonest are "bronzes" (see articles "Bronzes" and "Copper"); English metal or white metal (Britannia metal) which contains tin, antimony and copper with traces of iron and lead; German tin (Kayserzinn), of analogous composition is sometimes given the
name of "Urania metal". Modern English tin contains no lead.

In order to avoid lead poisoning in France a maximum legal limit used to be laid down of 16.5 per cent. in the composition of tin solder; now 10 per cent. has been fixed (a figure recognised since 1907 in Great Britain).

Antimony and bismuth are sometimes added with the object of hardening the metal and rendering it whiter. Zinc serves also in reducing oxidation.

The tin plates for stamping music contain tin (27.3), lead (68.7), antimony (3.4) and copper (0.6).

The plates were formerly obtained by hammering; the measures and the cooking utensils by moulding, and bringing the different parts together with soft solder. The bronze moulds were first heated and smeared with red ochre and white of egg or powdered with pumice stone or sandarac. The moulded piece was finished by rubbing and hammering on the anvil. The articles were burnt with oil and rubbed with whitening. A lead tin alloy is also much in use for making small toys where sometimes the lead is present in proportions varying from 40 to 90 per cent.

The two most important uses of tin, however, are the tinning of iron plates or iron utensils and the preparation of solder.

Tinning.—In tinning the sheet iron is first pickled by dipping it into sulphuric acid, then into a weak solution of hydrochloric acid and chloride of zinc. Scouring is the next process, effected by rubbing with sand, then the article to be tinned is dipped into a bath of molten tin covered with tallow. If culinary utensils or lids are being made, they are rubbed, after tinning, with cloths dipped in sal ammoniac.

The tinning bath often contains a high proportion of lead, which may rise to 70 per cent. The workpeople then run the risk of poisoning, especially during the operation of wiping or dusting.

Tin is not only used for the manufacture of domestic articles, but especially for making boxes in industry and tins for holding jam. To answer its purpose the material must have such special qualities as resistance and malleability in order to withstand, without tearing or cracking, the operations of stamping and setting, which latter has almost universally taken the place of soldering.

The ingot is furnished in steel factories by the Martin furnace, on a basic hearth, yielding a metal free from phosphorus, homogeneous (by the process of tapping at the source) and possessing the indispensable quality of resistance.

The ingot, after being re-heated in a continuous furnace, is converted by rollers into large plates of a given weight and volume to the metre. The large plates are folded in sections, each yielding four, eight or sixteen black plates of the required size.

The tin plate vessel or "bidon" is brought to red heat in a roughing furnace into which from twenty to twenty-five flat slabs can be placed. They then pass to the rolling mill and are subsequently folded in a special apparatus and finally trimmed with shears. The sheets are separated, re-heated and the operation continues. The metal is folded a second, a third and sometimes a fourth time; by rolling after each operation there are obtained four, eight or sixteen sheets of double length.

It is the plates of least thickness which undergo doubling over the greatest number of times. The fine plates are finally trimmed to a right angle and separated by hand by women.

The product obtained is crude steel which has oxidised and in spite of the successive "heats" has been cold-hammered. The scale is removed by pickling in a bath of sulphuric acid, generally of 12° B. (and reaches 35° at the end of pickling) and at 90° C. to remove the rust without at the same time attacking the metal too much. The processes of dipping into and removal from the bath are done mechanically. Washing in water then follows. The washed plates are then piled in cast steel boxes and left for twenty-four hours in a continuous furnace at 1,000-1,050° C. in order to give the sheets great ductility (black annealing).

After separation the sheets are rolled in the cold state to give them a brilliant polish and remove all roughnesses so as to reduce to the smallest possible limit the quantity of tin necessary for tinning.

A second re-heating to 750° C., a white pickling with sulphuric acid at 6° B., and a washing in water follow.

The black plates used to be tinned by the grease process or in the bundle. The sheets on leaving the water bath had to be dried before passage through the molten tin, because, if they were not, the water would decompose and seriously affect the success of the operation. As drying the sheets by hand was too costly and lengthy, they were dipped into a bath of molten grease where the water did not decompose but evaporated. The sheets then passed
into the tinning crucible at the optimum temperature. This bath was covered with a layer of grease a few millimetres in thickness with the object of preventing oxidation in the metal bath. The next process (brushing) consisted of placing in a holder containing molten tin, at a lower temperature with a layer of grease on the surface. The plates, during this process, were freed from impurities, dross, and the excess of tin which collects on the surface. Once brushed, the sheets were taken to the further bath where they awaited their turn to be introduced into the subsequent bath for the most important process, "tinning".

Generally speaking even with quite smooth sheets the layer of tin adhering on leaving the crucible was always too great and it was necessary to remove it and recover the excess of tin. Each sheet used to pass between two or three pairs of rolls where it was strongly pressed. The operation took place in oil or grease at 350° C.; the tin entered in a molten state (its melting point is 232° C.); ran along the sheet and fell to the bottom of the bath.

This method is to-day replaced by chloride tinning or sheet tinning, which is cheaper. In this process zinc chloride plays the role of grease in an almost boiling state in order to dry the metal to be tinned. As a matter of fact the chloride resting on the surface of the molten tin (its density being below that of tin) dries the fine sheet before it meets the subjacent layer of molten tin as it is very hygroscopic and the water evaporates. In the adjoining bath palm oil takes the place of the melted grease above the fused tin. The sheet arrives in this bath and is directed by a guide between two pairs of cylinders which roll it and rid it of the excess of tin. Thus the five or six processes needed in the older method are now replaced by a single one.

In Great Britain the old method, in which the Abercarn crucible was most commonly used, has given place to a new process bearing the name of the first factory to use it, "Melin Griffith". This method enables the tinning of iron plates to be carried out automatically as the sheet, introduced into the machine at the moment of dipping in the acid bath, is not handled again by the workman until the stage of sorting and packing is reached; handling is only required in exceptional circumstances. Without entering unduly into details (these were described by Collis and Vernon in 1925) it will suffice to say that the new machine ensures for the workman better conditions than those attainable by previous methods; less radiation of heat, a lower temperature in the neighbourhood, more rapid current of air, and less escape of fume and dust. Although the work of charging the furnaces is more arduous, nevertheless less physical force is needed and work is less monotonous than with the Abercarn process.

The black plates thus obtained are greasy and it is necessary to free them of this before any other operation is done, especially so when they have to be pressed. For this purpose the sheets are passed through a mixture of plaster and sawdust; the cylinders receive and subject them to rollers covered with felt or rubber alternately with rollers covered with sheep skins. This brushing operation is repeated by passing the sheets through rollers of another kind arranged perpendicularly to that where they had first been placed. Sorting and packing follow. By washing the surface of sheet iron with a solution of hydrochloric and nitric acid the "watered metallic appearance" is obtained.

Many tin articles (capsules, tubes, etc.) are made by stamping leaves of tin, or more commonly by stamping sheets of lead sandwiched between tin sheeting.

Solder. — Solder is an alloy of lead and tin. In ordinary solder the two metals are in equal proportions. Hard solder contains two parts of lead to one of tin. The manufacture and use of solder presents some danger (see article "Soldering (Lead)"). "Putty powder" is a combination of oxide of tin and oxide of lead and is used in the manufacture of enamels and in polishing. It is prepared by heating an alloy of tin and lead. In cut glass windows a putty powder can be used which contains no lead (see article "Glass").

Sources of Risk

The work of extraction of tin does not present serious risk for the workmen employed. The presence of silica, however, in the veins of the mineral may favour the occurrence of respiratory diseases. Though the state of health of English miners is sufficiently serious, special causes have been at work in bringing this state of things about. Thus, many of the men emigrated to South Africa so that the personnel left to start work in the mines was physically below normal. Further, the workmen who returned from South Africa, where they had worked in the Rand mines, sometimes showed lesions of the respiratory organs, and they offered but slight resistance to causes of damage.
The metallurgy of tin does not create special dangers. It will suffice merely to mention the possible risk from carbon monoxide poisoning.

Tin cannot be regarded as an industrial poison because it is very difficult to find conditions under which any serious quantity of the metal can be absorbed into the system.

Lehmann's experiments have shown that 10 to 14 mg. of tin per kilogram of an animal body weight, taken over a period of from thirteen to twenty days can be tolerated. Salant (1914) has studied the absorption of tin by rats, administering to them 10 to 50 mg. of tartrate and chloride of tin for twenty-three days; then 20 mg. for three months. Salant did not find any obvious symptoms except a tendency to emaciation after very big doses (50 mg. per kilogram weight).

The stannic compounds exert only a slight action. They are used largely in the colour and varnishing industries. The chloride causes dermatitis in dyers and tinsmiths as a result of its caustic action. The tetra-chloride used in charging silk, has set up trouble as described by Jolles, Salzer, and recently (1927) by Pedley. According to the American Bureau of Mines the presence of 8.5 parts of tetra-chloride per million of air causes coughing; a content of 3 mg. per 1,000 is tolerated by a worker, whereas 10 to 15 mg. per kilogram weight causes coughing; a content of 0.085 mg. in the atmosphere, which is thick, window panes are covered with soot, etc., unless measures to improve hygienic conditions are adopted.

In the manufacture of tin plate the different sources of injury are heat, steam, dust, acid gases, fatty vapours, etc. These pollute the atmosphere, which is thick, window panes are covered with soot, etc., unless measures to improve hygienic conditions are adopted.

In this industry besides the risk of poisoning from the metallic vapours and from arsenuretted hydrogen gas the lesions due to handling the sheets must be borne in mind: injury to the hands and legs; risk of burns; the heavy work of carrying the sheets and handling the heavy strips.

The acid bath is kept in a vat lined with sheet lead and cases of lead poisoning have been reported among the cleaners, the lead having been dissolved in the acid (Maisoneneve); this source, however, has not been described by Layet.

The well recognised effects set up by the fumes given off in the course of galvanising the sheets were made the subject of an enquiry by a Committee in Great Britain in 1926. The enquiry covered the use of sulphuric acid which often replaces hydrochloric acid in the process of pickling; the use of mechanical means of lifting the sheets into the pickling baths and the use of hoods to remove the acid fumes, and the possibility of applying local exhaust ventilation. The Joint Commission appointed a sub-committee in 1926 to study the ventilation of galvanising workshops, but the sad plight of the industry at that time did not allow the enquiry to complete its labours. Nevertheless in many instances improvements have been effected. On the other hand, contact with the acids has been the cause of localised damage to the hands and arms, especially amongst those men employed in measuring the degree of acidity in the bath and testing all the time in order to ascertain whether the submerged articles have reached the desired condition.

Maintenance of a red heat in the furnaces is a cause of ocular troubles and particularly of cataract.

In the manufacture of capsules and tubes, etc., where the tinfoil is handled, cases of lead poisoning occur now and then. This, too, occurred fairly often among the workpeople engaged in the process known as "suction" in the tin ware industry. This operation consisted in drawing in the air with the mouth from the inside of hollow pieces so as to test their airtight condition.

**STATISTICS**

In Great Britain a high mortality from tuberculosis has been shown to exist among the tin miners. The figures for 1910-1912 give the following comparative mortality rates: from all causes 2,190 (as compared with 1,000 for the whole male population); pulmonary tuberculosis 851 (186); respiratory diseases 768 (174); accidents 68 (58); bronchitis 286 (57); pneumonia 81 (90).

Incidence of lead poisoning among tinders, makers of capsules, etc., is not high; it generally takes a mild form. For Great Britain the number of notified cases of plumbism in tinning is as follows: 1921: 6; 1922: 5; 1901, 10; 1902, 11; 1921, 1; 1922-1923, 4; 1924, 3; 1925, 4; 1926, 2; 1927, 3.

The figures of 1921-1923 for mortality (Registrar-General's Occupational Mortality Report) among the tin and copper miners of Cornwall is much above the average (as much as 41/2 times as high as the general rate). Despite reasons
in explanation of the gravity of these facts (as e.g. return of miners suffering from silicosis from the Transvaal, etc.) it has to be admitted that the excess mortality among miners is higher than that in any other class of work. This excess is very high in middle life (four times the average for the age-group 35-65), and, for the age-group 35-45, it reaches the enormous figure of 450 per cent. Tuberculosis is present 12.5 times more frequently than the average; respiratory diseases 6.3 times. The mortality is also high for diabetes, cerebral haemorrhage, chronic nephritis, myocardiitis, and even for cancer, which would not appear to have any connection with the work of tin mining. Readers are referred to the original report mentioned above (page LXVII) which contains very interesting details, too long however to be quoted in full here.

So far as tinsmith's work is concerned, the death rate from all causes only exceeds the average by 1.1 per cent, and does not offer any characteristic features. In France the cases of lead poisoning from tinning are not numerous and it is the same for the manufacture and manipulation of metal capsules for bottles.

The inspectors of factories in Germany, however, brought light in 1913-1914 in tin plate works and concluded that respiratory affections were fairly frequent among them.

Further, Udo J. Wile has described the special lesions found among animals working near the foundries in the copper and tin mines in Cornwall which are attributable to arsenic. In tinning of iron plates the workers may suffer from dermatoses as well as from injuries which in themselves lead to skin affections. Thus for example Fischl, in a capsule factory at Breslau, found eruptions on the lower third of the forearms, taking the form of papules, pustules, livid bluish areas, as well as on the external surface of the thigh, and on the back of the foot. The lesions itched much, but were not accompanied by constitutional effects. Fischl thought that the cause might have lain in the tin or lead or cleaning oil.

The lesion described has also been spoken of as "tin itch" among tinsmiths and among workmen coming into contact with capsules made of tin.

In addition to injuries to the hands and forearms mention should be made of the condition described by Mori of damage to the Achilles tendon which is characteristic of persons working on tinned strips. The lesion occurs to either the workman engaged in bending the strip (and precisely to the foot which has to exert pressure on the sheet) or to the workman beside him who is affected by the strip as it leaves the roller and is tossed on to the metal floor of the workroom. The strip glides along, jumps and generally strikes the workman on the Achilles tendon.

The skin of the picklers appears to be bleached and hardened by daily contact with acid, and shows cracks and numerous excoriations, especially at the articual folds. Sometimes the sensitiveness of the skin is diminished; the workpeople complain of numbness of the extremities.

Inside the mouth a chronic irritation of the gums bordering on the teeth is noted. The majority of old picklers are edentulous; the gums are pale and hardened; around the teeth and remaining stumps they take on a bright reddish colour with slight sponginess. The teeth and stumps are blackened and rough. Gradual change takes place in the enamel and tooth dentine which becomes smaller and smaller until it breaks at the base.

Possibly changes in the saliva and teeth brought about by the acids induce dyspepsia in time with gastralgia of which the picklers complain.

Slight irritation of the conjunctival mucous membranes of the nose and throat are also reported, but no spastic forms of bronchitis origin nor asthmatic attacks.

If the apparatus is not completely protected by a hood connected up to an efficient exhaust, the fumes, escaping freely into the atmosphere of the shed, set up coryza, dryness of the throat, oppression, sometimes marked, in the chest, loss of appetite, emaciation, etc. Collis and Hilditch in 1911 examined a thousand persons employed in tin plate works and concluded that respiratory affections were fairly frequent among them. But the data obtained as to tuberculosis were not sufficient to enable definite conclusions to be drawn.

Of the tinner examined by Walther 22.9 per cent. were found to have myopia. Leaving aside those of school origin he was able to say that the occupational origin was very frequent (15.6 per cent.)

Cataract was found by Healey (1921) among 200 steel workers aged thirty-five years and over, who were exposed
to the action of the heat rays. Among 350 workmen of thirty-five years and over he found opacities of the lens as follows: 35-40 years, 17.5; 41-45 years, 18; 51-55 years, 62; above 55 years, 65.

The cataract showed itself in two forms: a posterior cortical cataract similar to that occurring among glass-blowers and finishers, and in the form of a cortical opacity, in striae, wedge-shaped, with the base directed below.

The lesion is invariably found on the side exposed to radiant heat.

The English statistics tend to show that incidence of tumours is higher among tin and steel workers than the average. The presence of arsenic in the mineral might be thought of as explaining this frequency. Diseases of the nervous system and urinary tract are also higher than the average.

The incidence of lead poisoning among persons engaged in making capsules for bottles has been studied in Germany by Laurisch (1898) and Rasch (1900); in Italy by Carozzi (1909), etc.

Lastly, it should be recalled that Paschkis described in 1912 dermatoses due to the use of a bath of tin (chloride) and hydrochloric acid to charge silk. The lesion affected the fingers of the right hand and thumb of the left; it commenced as a round ulcer, fairly deep, with well-defined edges and of a brownish red colour. In 1927 Pedley had occasion to treat a workman sixty-six years of age who for thirty years had been in contact with tin tetrachloride for the purpose of dissolving it in hydrochloric acid. The patient complained of sore throat, a feeling of coldness in the chest (not in the extremities), morning sickness, pains in the shoulders and lower limbs, constipation, cough, etc. Pedley attributed the symptoms to neurasthenia. Nevertheless tin was found in the urine and faeces. The same symptoms were observed by Jolly (1901) and in a case studied by Salzer (1918). The first case was that of a woman who had worn socks dyed with a tin salt (she had paralysis, anaemia with albuminuria, cachexia). In the second case the patient was a man who wore false teeth — an upper and a lower set made of tin to the extent of two-thirds.

DETECTION

There rarely occurs in practice the necessity for detecting the presence of tin. For research methods in this connection the reader is referred to a text-book of toxicological chemistry.

HYGIENE

In tin mines the same measures should be adopted as are taken in mines in general. In Cornwall the following have been adopted: lowering the dust content in drilling by a water spray or other efficient method; prohibition of resumption of work under half an hour in a place where a mine has been exploded, in order to give time for the dust to settle and for ventilation of the spot; wearing of respirators, wet crushing and grinding of the ore or other efficient method, etc.

While in the metallurgy of tin or in the manufacture of the plates, tending the travelling belt usually adopted does not involve serious risk for the workmen, nevertheless the rolling and doubling, etc., of the black plates, work at the furnaces, the bending of the plates rough trimmed by hand, and separating them expose the workmen to high temperatures. Near the furnace and rolling mills the temperature reaches 400° C. and the fat which serves to grease the material is constantly converted into smoke and flame by the bearings.

In front of the furnaces a plenum system of ventilation pumps in pure air at a height of 2½ m. from the ground. Opposite the furnace man and the roller man vents controlled by dampers direct the air currents over the workpeople at a speed which can be calculated not to inconvenience them by chilling them too much and yet at the same time to give an adequate air supply.

Pickling, carried out at a temperature of 90° C., naturally occasions acid fumes (sulphuric acid). The automatic lifting enables the workpeople to remain at a convenient distance from the tanks, and consequently outside the range of obnoxious fumes. In order to remove the fumes from the workroom the tanks and apparatus are provided with hoods which hinder all re-entry of air likely to throw back the injurious fumes, which would enter the lower part of the hood and so get into the workroom.

In order to prevent all dissemination of the fumes of tin, palm-oil, hydrochloric acid, zinc chloride, etc. — fumes which are injurious as well as disagreeable — given off in the course of tinning and scouring, recourse must be had to different systems of localised ventilation. At the same time the work must not be interfered with while ensuring the protection of the workpeople from the fumes. On the other hand the palm oil vapour, especially in winter time, on coming into contact
with the side of the hood, liquifies and runs down to the edge of the hood.

The degreasing agents (plaster, sawdust) are heavy and tend to fall down, whilst the system of exhaust ventilation for the fumes tends to draw them towards the roof of the shed. The dust is thus subjected to a kind of mixing without being got rid of.

This is why in factories where this question has been carefully studied and where the methods employed for increasing the output have brought many inconveniences to light, it has been decided that tinning and degreasing should be kept separate from scouring.

The workroom for tinning and degreasing is divided into two parts, one of which is a large hood equipped with louvres in which the ascending force of the fumes at the immediate moment of their production is utilised. By the side of the ordinary means of air entry there is an additional one which can be regulated according to the wish of the tinner. The arrival of the black plates at the tinning crucible is effected by a mechanical travelling endless belt which is attended to, just as is a printing machine, by one workman, who is not inconvenienced by the smoke or fume of palm oil as he is at least 2 metres away from their source. Similarly an identical arrangement carries the sheets to the place where they are scoured. Here the dust given off is of little importance as the dust raised is made to fall to the ground. Maintenance of a slight negative pressure increases this tendency, bringing the plaster and sawdust into a channel and so preventing them getting into the workroom.

LEGISLATION

Women and young persons under eighteen years of age are prohibited in France from work in sheet iron and varnished metals where toxic substances are used.

A special Code of Regulations controls work in metalliferous mines in Great Britain (see Mines Regulations, 1911). Welfare Orders referring to tin plate works came into force in 1907 (No. 1035), and in 1909 (No. 750) Regulations for tinning of metal hollow-ware, iron drums and harness furniture have been enacted.

In France a Decree of 1 October 1913 prohibits the operation of testing airtightness by suction with the mouth (pompage) in the tinware industry.

Lead poisoning from tinning is scheduled for compensation in France, Great Britain and Russia, as is also the case with mercury tin amalgam in France and poisoning by tin chloride in Switzerland.

For compensation for cataract see article "Occupational Diseases: Eyes".

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Titanium


Titanium (symbol, Ti) is a metal (metalloid) which is not as rare as has been believed up to the present. Its chemical properties are closely allied to those of silicon. It is found as a dioxide in certain minerals, known as rutile, brookite and octahedrite; the first is the only important one from a practical point of view. In the form of titanate, titanium is found chiefly in perovskite, ferrocalcic titanate (CaFeTiO₃), and in titanite silico-titanate of calcium (CaTiSiO₄). It is also found in zirconates and vanadates, in numerous salts of lime, of iron and of manganese, and in oxides of rare metals. The most abundant mineral source is titanate of iron, or ilmenite; with 25 to 55 per cent. of TiO₂.

Titanium was obtained in the free state by Berzelius. To-day it is obtained from its oxide by heating it with very finely powdered aluminium. It appears as a grey metallic powder or
as a mass resembling steel, being just as hard and as difficult to melt, but it can be worked at a red heat.

In industry it is added to steel up to 10-15 per cent. in order to make the steel more resistant (ferro-titanium); to carbon and tungsten for the manufacture of electrodes, electric lighters and the filaments of incandescent lamps. It is used as a catalyst in the synthesis of ammonia, and for absorbing the last traces of water in vacuum bulbs used for electric lamps and X-ray tubes, as titanium readily absorbs oxygen and nitrogen.

Among the most important compounds are: chloride of titanium, which has a pungent smell and fumes on exposure to the air, giving off hydrochloric acid and titanic acid; it is one of the most powerful-reducing agents, and is used as a mordant in dyeing and for dyeing skins; tetrachloride, which is used in the preparation of the trichloride and other salts of titanium; iridium, iridium is a suitable rate, and, during the war, of smoke screens; the tannate, which is used as a mordant, and, especially, the double oxalate of titanium and potassium; ferro-cyanide, a green pigment destined to replace arsenical pigments; sulphocyanide, a strong reducing agent, used also in dyeing; and, finally, natural oxides, rutile and ilmenite, used in ceramic work for glazes. Among the most important compounds in use is white or oxide of titanium (TiO₂), which is used as a mordant in dyeing, as a pigment or body in the India-rubber industry and as the pigment of artificial plastic materials, oilecloth and linoleum, and in the preparation of rice powders and beauty creams.

It is chiefly in the paint industry that it has acquired an ever-increasing industrial importance. In 1906, the waste from the treatment of titaniferous bauxite was used for the first time for the preparation of paints and mastic, and, at the same time, in Norway efforts to treat ilmenite to produce iron led to a process for manufacturing a white pigment from titanate of iron or ilmenite. Numerous investigations led to industrial trials in America and Norway, and to several processes, most of which have now been given up. It was in this way that the chloride process did not become industrialised, although it may one day be used for the extraction of pure titanic acid from some ores of titanium. There are seven processes of preparation (Cartorot and Devaux, Princetown and Monk-Irvin). Among the processes adopted, one of the most extensively used is that based on the treatment of ilmenite with sulphuric acid; ilmenite is attacked when it is heated in large cast-iron receptacles at about 120° C. with concentrated sulphuric acid. The product of the reaction is dissolved in water, then decanted to recover the mineral not attacked; and the ferric salts present in the solution, which might interfere with hydrolysis, are reduced by nascent hydrogen. The resulting sulphate of titanium is a somewhat complex product and contains also sulphate of titanyl.

One of the most important phases in the manufacture is certainly the operation of heating the titanic acid solution with sulphuric acid in the presence of water. After clarification, in order to remove small quantities of colloidal substances present, the sulphate is allowed to crystallise between cooled rotary crystallisers. The oxide of titanium is then centrifuged, concentrated in a vacuum, heated and precipitated by hydrolysis by diluting at a suitable rate. Next, the oxide of titanium, which still contains sulphuric acid, is filtered on acid-resisting filters. It is washed and neutralised with a volatile alkali. Next, it is treated with given quantities of colloidal solutions of oxide of titanium, digested separately with hydrochloric acid. A colloidal gel of oxide of titanium is obtained which is filtered, dried and calcined in a rotatory furnace, at 900° to 1,050° C., so as to make at least a fixed fraction of the oxide of titanium pass into a microcrystalline state. It is this final operation which decides the quality of the product. The new bodies formed take on more and more a colloidal character.

Titanic acid in the form obtained by hydrolysing the purified solution of titanyl sulphate is a white powder, possessing a new structure. The oxide, on being taken from the furnace, is disintegrated in a crushing machine, which pulverises it into extremely fine particles. After a final washing the pigment is freed from moisture, then thoroughly dried, and passed into an air-separating apparatus in order to isolate a light powder, with great homogeneity of particles, possessing a specific gravity of 3.7, compared with white lead 6.4, zinc oxide 5.5 and lithopone 4.15, and having an index of refraction lying between 2.30 and 2.60, one of the highest of the various white pigments. In some factories "composite pigments" are prepared, in which titanic acid is the element giving to the material quality and colour, as well as that body which is normally provided by sulphate of baryta; in other factories very pure titanic acid
is prepared, which is used in different ways in the industry for paints made with oil, alcohol or with mixed solvents and cellulose varnishes.

To-day oxide of titanium plays a part of first importance among the white pigments which may be used in substitution for such toxic pigments as white lead and lead sulphate. While some experts maintain that pigments of titanium are more difficult to make into a paste than those of zinc, and do not react with drying oils, industrial practice, on the contrary, shows that the problem of how to use pigments of titanium is being solved in a very satisfactory way.

Oxide of titanium is of all the pigments the one which gives particles of the smallest size (1 μ for titanium against 5 to 10 μ for white of zinc and 50 to 80 μ for white lead); further, oxide of titanium is the lightest of the white pigments used in the painting industry. Hence, its fineness and lightness ensure stability to its suspensions.

As regards covering power, without entering into details, which are to be found in the works of Olsen (1921) and Noel-Heaton (1922), quoted by Vila, mention is here confined to remarking that the values obtained in the last of these returns under "weight of white lead" and "weight of pigment" show that white lead always has a covering power inferior to that of zinc oxide, considering the weight deposited, and, at most, equal to zinc oxide when the volumes of these powders are taken into consideration. The same covering power of lithopones slightly exceeds that of the oxides of zinc of an equal quantity. The covering power of whites of titanium made up with 25 per cent. of TiO₂ is only slightly superior to that of lithopone; but the pure pigments alone have a covering power decidedly higher.

Although pigments of titanium have a weak affinity for oil, it is nevertheless possible, according to American and Norwegian investigations, to obtain more stable coatings when the pigments made from titanium are mixed with other substances. The substances, introduced to give body to the materials, with the object of lowering the price, are now becoming means for improving the product, if introduced in the right proportions and under favourable conditions.

The paint industry has at the present time succeeded in overcoming the difficulties which prevented titanium from being effectively crushed, difficulties which were certainly greater than those met with in the case of zinc oxide and lithopone. By means of perfected apparatus, titanium can very easily be formed into a paste with 15 per cent. of oil.

As regards solidity and protective properties, it should be said that at the present time there can be found on the market paints made with a basis of titanium which, for solidity and protective power, are at least equal to products made with a basis of other pigments.

The value of a paint depends on several factors, which are not, however, of equal importance when estimating the value of paints made with a basis of different pigments. Thus, for example, the active reaction of the basic pigments with the acid bodies which are formed during the oxidation of the drying oils — a reaction which renders the coatings obtained with these pigments more resistant — cannot be claimed, or only in modified terms, for pigments of titanium, even when they contain appreciable quantities of one or the other of the known pigments. Technique answers this objection by oxidising with heat the drying oils as a preliminary, so as to make them lose a large part of the acid products which tend to form in the cold state. The problem of a good paint with a basis of titanium is somewhat complicated. But by the help of a better combination of titanium either with the active pigments or with the body, by the most careful selection and treatment of the binding substance and the diluents, and, further, by means of a formula for the composition of the paint, corresponding to practical requirements, the industry has obtained products giving every satisfaction.

It cannot be hoped that the use of titanium white will be developed by modifying the titanium oxide industry, but rather by an improvement in the paint industry in general. By enlightening as to the substances available for use and as to the special characteristics of these products, the industry may be persuaded to make intelligent use of such substances, as is already the case in the linoleum industry and that of artificial india-rubber.

**Pathology**

Oxide of titanium is devoid of toxicity in consequence of its chemical inertia. Some experiments made by Schoofs in 1927 on guinea-pigs showed that food mixed with titanium white does not cause any disturbance. Kerkhof did not find, post-mortem, any trace of
titanium other than in the alimentary canal.

Lehmann and Herget (1927) also showed experimentally that oxide of titanium is not absorbed by the body and that it does not exercise any toxic effect. After having administered to animals, for periods reaching sixteen months, varying doses of oxide of titanium, either alone or in the presence of mineral and organic matter, these experts did not find any trace on chemical examination of the principal organs, with the exception of the digestive tract, which contained a quantity corresponding to the dose administered. During life, the animals did not present any special disturbance and autopsies on the killed animals showed the organs to be histologically healthy.

In 1928 Vernetti-Blina, by exposing dogs to the effect of oxide of titanium introduced by the respiratory or digestive route, or subcutaneously, was able to show, more than once, a complete absence of toxicity for titanium white. The same expert confirmed his observations on workmen employed in closed workplaces on operations which gave off titanicate oxide dust. Clinical examination of these men, and even radiological examination, showed that any appreciable lesion was absent.

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**Tobacco**


Tobacco is considered to be one of the most insidious poisons against which humanity has to protect itself. Tobacco was discovered in America in the Island of San Salvador, by the men who went out with Columbus, and was introduced into Europe by the Spaniard Friar Thvet in 1517; its diffusion is due to the naturalist Hernandez, of Toledo. It is an interesting fact that some seeds were sent from Portugal to France by the Ambassador Jean Nicot de Villemain, to cure Catherine de Medici, who had long suffered from neuralgia.

The medicinal properties of tobacco had been recognised in the country where it originally grew, and this was an important factor in favour of the new product. But whereas in France the use of tobacco spread under the name of "Queen's herb", elsewhere its introduction was fiercely opposed; its use was strictly forbidden under pain of very severe penalties. However, by degrees all classes, including persons in the highest social position, were won over to favour the adoption of tobacco. Then persecution on the subject ceased. Richelieu was the first to impose a duty on tobacco, thus converting a vice into a source of revenue to the State. At time went on increasingly well-organised monopolies ended in becoming virtual State industries in some countries. At first tobacco was used as snuff; the habit of smoking it was not adopted until later on, when the soldiers of the French Revolution and those of the Empire set the fashion.

The recent war completed the establishment of this dangerous habit, particularly among women and quite young persons.

**TECHNICAL FACTS**

Tobacco is a herbaceous annual, sometimes a bi-annual, plant, of the solanaceous family, which includes fifty species and sub-species. It received the name of Nicotania Tabacum in memory of Jean Nicot. It is produced chiefly in the United States and in British India; but the favourite kind on the market is that which is grown in Cuba. In Continental Europe Oriental tobacco is the most popular.

The tobacco plants are grown from seeds, sown in hotbeds, in nursery gardens, in garden frames or greenhouses. The seedlings are pricked out and transplanted in cultivated fields. In March, and at the beginning of July, the grower starts to pull off any withered and dirty leaves near the ground, and also any branches of flowers; then he gathers the other usable leaves as they gradually turn yellow. The leaves are put to dry in the sun for several hours, and then are threaded on a stick one by one, and carried to the drying rooms. The leaves are cured either in the sun or in the shade, or with artificial heat, according to the quality of the tobacco. There is no universal method. The cured leaves are sorted, tied up in bundles or "hands", and, in January, arranged in heaps, the object being to induce a first fermentation.
The leaves are sent to the factories wrapped in cloths. A first selection is then made, so as to separate the leaves for various types of tobacco. The leaves are then shaken, and beaten, so as to get rid of all dust and grit, and arranged in layers, each layer being sprinkled with a solution of 5-10 per cent. of sodium chloride. At this stage sometimes a second fermentation is allowed to take place; it is obtained by means of washings with weak solutions of salts, alkalis or acids. Improvement of the flavour and the aroma is obtained by "steeping", i.e. immersion of the leaves in a special solution, each factory having its own particular recipe. The leaves are drained or pressed, and are then left in the mass, sometimes for a long period, sometimes for a short period. There are special machines for removing the stems from the leaves, and, if necessary, for cutting them into strips. Next, the leaves are torrefied; then they are dried and rapidly cooled in a current of air. Finally comes the preparation of the cigars, cigarettes and snuff—all of which is to-day done almost entirely by machinery.

The cultivation of tobacco, especially in countries which are chiefly given up to small holdings (metayage), is left to the women and children, as it only entails light work which is fairly remunerative, and because in this way all members of the farmer's family can be employed.

An enquiry into the conditions of labour in the tobacco industry in Java was made in 1928 by the Volksraad of the Dutch Indies. According to this enquiry, tobacco is cultivated on land belonging to the villages and rented for one year to the manufacturers. The village land is divided into five sections, of which one-fifth is reserved for the village communal requirements; two-fifths are let to the tobacco manufacturers and two-fifths to the coolies. In the fields the cultivation of tobacco by the manufacturers, and of rice by the coolies, is on an alternative system, so that a field planted with tobacco one year may be cultivated the following year by a coolie on his own account. As a rule the coolies and their families supply the labour for the tobacco plantations. Whilst cultivating their rice fields, they increase their income by working at the same time for the tobacco manufacturers. In this way the coolie can claim half the rice crop which he has grown in the fields let out, after the tobacco has been harvested; one-half is his in return for his labour, and he can buy the other half at reduced prices.

In fixing the hours of labour, the manager of the plantation takes into account the fact that the coolie must also have time to work on his rice plot.

There are a good many stages in the work that has to be done in the fields up to the time when the tobacco is harvested, and it goes on for several months. The coolie, helped by his whole family, children included, works in the drying rooms, which are built of bamboo, and are situated quite near where the coolies live. Sorting operations take place in large sheds, which are considered to be enclosed premises, and thus, according to Order 25, children under twelve are excluded from work in them. The different operations which take place in these sheds are carried out by men or by women, according to the nature of the work.

**TOXIC ACTION**

There are two classes of tobacco: mild tobacco, containing 1 to 2 per cent. nicotine, and strong tobacco, with 6 to 10 per cent. Fresh or dried tobacco is more toxic than the manufactured product.

Tobacco contains several poisonous substances: nicotine, nicotianine, nicotinie, nicotene, nicotelline; and traces of malic, citric, oxalic and nitric acids. In tobacco smoke there are to be found pyridine, picoline and collidine, as well as gases of hydrocarbons, carbon monoxide and carbon dioxide, ammoniacal salts, especially cyanide of ammonia, and cyanogen.

Of all the poisons mentioned above, the most poisonous, and, from the point of view of occupational hygiene, the most interesting, is nicotine \((\text{C}_{10}\text{H}_{14}\text{N}_2)\).

Nicotine is a strong bivalent base, united to malic and citric acids. It occurs as an oily liquid, boiling at 247° C., with a strong smell; it is soluble in water, alcohol and ether, and turns brown when exposed to the air. It may be obtained from an ordinary extract of tobacco, and also synthetically, starting from \(\beta\)-amino-pyridine, salified with mucic acid.
Nicotine has been known in its impure state for a great many years, for in a book dating from 1686 Brogiani, of Florence, mentions an oil from tobacco capable of killing animals in a few minutes; Lemery, in 1696, speaks of a poisonious oil which is obtained in the course of the dry distillation of tobacco, and Vauquelin, in 1809, draws attention to the presence of nicotine in tobacco leaves. It was isolated in the pure state in 1828 by Posselt and Reinmann.

Although pure nicotine is very toxic, this fact has been exaggerated; 5-10 cg. will kill a large dog quickly; a dose of 20-21 mg. per kilogram kills a rabbit (Grasset and Parenty, quoted by Kohn-Abreast).

Tobacco causes both acute poisoning and chronic poisoning. The channels by which it may enter the system are the digestive tract, the respiratory passages and the skin, but it is only the latter which are of interest from the occupational point of view. The channels of elimination of the poison are the urine, saliva, sweat, and possibly the milk.

Occupational poisoning may appear in the acute form, or the chronic. However, tobacco poisoning is never found in people who are employed in the cultivation of tobacco, not only because their work is not continuous and lasts a short time, takes place out of doors and alternates with other forms of agricultural activity, but chiefly because, in the green leaves, only superficially dried, the nicotine is united with the organic acids, and because in the dried leaves it is only liberated slowly and in small quantities in ammonia, water and carbon dioxide (Allevi). It is only during fermentation when the leaves are being prepared for cigars that nicotine is liberated.

This absence of risk from poisoning is not only characteristic of strictly agricultural work, but also of labour of preindustrial nature, which deals with the preservation and utilisation of the tobacco before it is sent to the factories, i.e. sorting, putting in boxes and packing.

After an enquiry in 1915 on the manipulation of Oriental tobacco as it is carried on in the province of Lecce (Italy), Carozzi came to the conclusion that the fact that the various operations are carried out on withered leaves which have not as yet been subjected to fermentation, capable of transforming the organic substances (acids or bases) present in the leaves, explains the innocuousness of this work, although in the course of the various manipulations a small quantity of nicotine is liberated, estimated actually at 0.2-0.3 per cent. But as this always remains in the leaves united with organic acids, it cannot be liberated or pass into the surrounding air as a harmful agent.

When the tobacco reaches the factory it becomes a source of danger, chiefly in the processes of sorting and fermenting the leaves, and in the manufacture of cigars. The workers are exposed in the first case to the inhalation of tobacco dust; in the second case to the inhalation of injurious fumes; and in the third to the contact with the wet tobacco leaf.

Ramazzini was the first to recognise the injurious nature of work on tobacco. But whereas many experts have confirmed the opinion of the Italian scientist, others have contradicted it, and have even put forward the opinion that work on tobacco can prevent and cure infectious diseases, among others tuberculosis.

No one disputes the local action of tobacco dust and juice, especially during the first months of work. This action is observed on the skin and on the exposed mucous membranes. It has even been stated that tobacco dust and juice finds its way, or is conveyed by the unwashed hands, to the genital regions, especially in the case of women, and causes conditions of irritation, which often extend to the vagina.

The general symptoms caused by tobacco may be produced by the dust inhaled or swallowed, by the fumes which are liberated during certain operations, especially fermentation, and by carrying food to the mouth with hands that have not been carefully washed and are soiled with tobacco dust or juice. Hencke found in the tobacco dust of certain factories 0.56 per cent. of nicotine.

Chronic poisoning in the case of workmen who handle tobacco has long been a question of debate.

In France, Pointe in 1828 drew attention to cases of purpura among the men who worked in factories at Lyons; in 1842 Viscount Siméon published a summary of reports from doctors who were attached to the French tobacco factories, according to which the workers appear to have exhibited a power of resistance to infectious diseases superior to that of the population in general: at Morlaix this was proved in the case of an epidemic of dysentery, and at Tonneins of sweating sickness, which raged among the rest of the population.
But Ygonin in 1867 and Poisson in 1881 expressed doubts in regard to these statements.

There are available reports of numerous enquiries on the influence of tobacco on the development and evolution of tuberculosis among the workers in the factories. There is no doubt that tobacco dust can cause irritation of a mechanical and chemical nature of the upper respiratory tracts. But whereas in the early days the conclusions arrived at pointed to an injurious effect on the health, more recent enquiries have resulted in contrary conclusions.

In 1885, for the first time, the Baden Office of Statistics felt they were justified in accepting the view that there was a connection of cause and effect between pulmonary tuberculosis and work on tobacco in the manufacture of cigars. In 1890, Worishofer drew attention to the extremely high death rate from tuberculosis among workers on tobacco; this mortality, however, was attributed by Thiele and Walther to other causes of a social nature, although the industry in question might influence the development of the disease among juveniles, especially where there were any persons suffering from open tuberculosis in the workshop.

A Swedish enquiry of 1921 dealing with nearly all the factory workers in this industry (84 to 98 per cent.) and including a systematic examination of the workers, showed that the number of cases of tuberculosis was no higher than that for the rest of the population. Similar reports have been issued in Austria by Jehle, in Spain by Oliva, in the United States, in Finland, in Italy by Celli, and in Great Britain; Brunbaum concluded his enquiry in Baden in 1926 by saying that this industry is free from danger to health for the workers, and that their state of health is the result of the social conditions of a poor population receiving low wages, with sub-normal constitution. The same opinion has been expressed by Muller, Berghaus and Borschatschewsky. The latter studied 1,658 workers in Odessa factories for five years, and in 1930 found symptoms of tuberculosis in 691 cases. But he is of the opinion that these cases were not due to the occupation, which does not appear to exert any predisposing influence towards tuberculous infection. It is true that results vary according to districts, and that in certain factories a higher incidence from tuberculosis has actually been found than in the occupational categories notoriously affected by this disease.

But this statement is only of relative value, for other factors besides the work would seem to play their part.

Further, this opinion has been modified in the course of recent years, through the use of more modern methods of diagnosis. Examination, even with X-rays, is said not to have shown the existence of pulmonary tuberculosis, although sometimes revealing a condition of tobacco poisoning.

Holtzmann in 1930 studied this industry in Baden, and came to the conclusion that bad food, poor housing and particularly the lack of segregation of the sick and healthy, the poor constitution of some of the workers engaged, especially some of the women, and also early sexual relations, are more important factors than that of tobacco.

Gross in 1931 has stated that in Dresden the rate of sickness among tobacco workers is not much higher than the rate of sickness for the general body of workers inscribed at the Dresden Insurance Office: tuberculosis, manifest or suspected, stands at 2.9 per cent. against 2.6 per cent. among the other workers; influenza at 16.3 per cent. against 17 per cent.; respiratory diseases at 12.9 per cent. against 12.6 per cent.; gastro-intestinal, cardiac and cutaneous diseases, as well as injuries, occur more frequently among the general body of insured workers than among tobacco workers. On the other hand, tobacco workers suffer more often from genito-urinary diseases, exhaustion, and nervous diseases, and Gross considers that this particular frequency can be accounted for by the large number of women among the personnel of the factory, which amounted at Dresden to 372 women for every 100 men.

In the opinion of Gross, nicotinism does not constitute an occupational illness among tobacco workers; he denies the existence of any pneumoniais, and does not consider that work on tobacco can render pulmonary tuberculosis worse. The respiratory troubles observed consisted in simple catarrhal irritations of the upper respiratory passages, and were chiefly found among the beginners.

In Italy, from 1922 to 1928, the mortality from pulmonary tuberculosis among the factory workers was 0.116 per cent.; thus it is lower than that in the large industrial centres (Fraccarela). Out of an annual average of 21,381 persons examined, 18,303 of whom were women, there were 249 deaths from tuberculosis.
In the opinion of Jötten and Kortmann, tobacco dust is the least harmful of the various kinds of dust with which the same workers came into contact. After several months of inhalation, the animals only manifested a very mild tendency to pneumoconiosis, and the elastic tissue had not been affected. This dust did not influence the development and evolution of the tubercle bacillus; and this infection did not become serious, even in the case of animals which had been poisoned previously. In fact one may say this dust does not play an important part in the production of any pneumoconiosis.

Another point about which there is much difference of opinion concerns the harmful effect of tobacco on pregnancy, and also on the child when it is born.

Whereas Delaunay, Decaisne, Quinquaud, Layet, etc., admitted that this influence was harmful, Ygonin, Lebail, Poisson and others have denied it, but have at the same time recognised that the sexual organs in a woman are stimulated to over-activity by tobacco.

As a matter of fact, several authorities have observed among women addicted to smoking a high incidence of disorders of menstruation, especially menorrhagia and a greater frequency of post-partum haemorrhage (enquiry by Giessen, 1906).

Nicotine has been found in the amniotic fluid by Ruef and Stolz; and in the milk by Kostial, although De Blasi and Simonini did not succeed in detecting it; for this reason it is thought that the action of the alcaloid may be harmful to the embryo or foetus as well as to the new-born child during nursing.

Guzzi and Resinelli La Torre among the gynaecologists, and Guido Pieraccini, Gayard and others blamed work on tobacco for an increased number of miscarriages among women who worked in the factories. On the other hand, Vaccari, Aymérich, Montuoro and Rossi do not admit this action of tobacco on pregnancy, and Monti held the opinion that there was a diminution in fertility.

As far back as 1897 an enquiry by Etienne among seventeen families in which there had been 93 cases of pregnancy pointed to the conclusion that tobacco had no harmful effect on pregnancy. The same enquiry brought out that, whereas the infantile mortality was more than double that of the general population, this could be reduced by providing facilities for the mothers who had returned to work to nurse their children, and also by prohibiting return to the factory for a minimum of four to six weeks after the birth of a living child. An enquiry by Courtois-Suffit in 1908 dealing with 17,000 French women workers confirmed the opinion that tobacco seems to have no influence on the births, and that miscarriages among these particular women were not more frequent than among the rest of the population. Among their children disease was not more frequent nor the death rate higher, so long as they were properly looked after, than in any other class. The children who were breast-fed by careful mothers developed normally, and exhibited no particular sign of ill-health for which the quantity or quality of the milk might be held accountable.

In Italy, Peri, Montuoro and Celli in 1906 came to the conclusion that the number of miscarriages and the infantile mortality were not so high as were found in other factories that were under observation for the purpose of comparison. From 1922 to 1928, in Italian factories employing 149,668 workers (128,163 women), with an annual average of 21,381 (18,303 women), there were registered 16,346 confinements, giving an annual average of 2,332, and 941 miscarriages, with an average of 3.75 per cent. of confinements.

Mention should be made of the effect of fumes liberated chiefly in the course of drying and fermenting the tobacco. The composition of these fumes has not yet been well determined; but special notice should be taken of their effect when they have been accumulating for several hours in close workshops, particularly during the summer heat. The fermentation generally goes on for some time, on an average for two months, and, although it is unusual for the air of the workshop to be contaminated to the point of becoming harmful to the health of the workers, it is quite a different matter when fermentation is accelerated, a process accompanied by a considerable liberation of gas and fumes. Here the rate of illness among workers manipulating the tobacco, which is undergoing artificial fermentation, is found to be higher than that observed among workers in contact with the "slow" fermentation.

Seiff in 1931 affirmed that the quantity of nicotine which is liberated from the apparatus used for moistening the tobacco, and from the bales of tobacco which are taken out of it, is considerable, as is shown by the table below:
in order to ascertain the degree of harm-
women declared they preferred work-
serious.
ness
cephalalgia, palpitations, intense sick-
diminution in visual acuity.
ning in the shade in the sheds rather

The other harmful products — carbon monoxide, carbon dioxide, ammonia and furfurol — do not seem to be taken into account. Out of 12 work-
men employed on the apparatus for accelerated fermentation, Seif found, during the season 1930-1931, that 9 men, aged from twenty-two to forty,
three years, were taken ill several times, and 4 of these were obliged to be absent from work during periods varying from eighteen to forty-three days. The sick men complained of cephalalgia, palpitations, intense sick-
ness and nausea, sometimes with diminution in visual acuity. Several of the men vomited during work, more particularly in the evening. A diag-
nosis was made of nicotine poisoning, with intestinal disorders, more or less serious. Five cases of gastric catarrh among the workmen were also attribu-
ted to nicotine.
The enquiry at Java mentioned above pointed out that in the sorting sheds the fermentation of numerous heaps of tobacco at a temperature of 50° C. and higher is bound to vitiate the atmos-
phere. It is difficult to remedy this trouble, as a certain degree of humi-
dity must be maintained constantly in the sheds, and so there can only be a moderate amount of ventilation. The investigators engaged on the enquiry observed, during the month of April, temperatures of 27.7° to 30° C. in the morning, and 31.1° to 33.3° C. in the afternoon. Yet the workers did not complain of the heat; in fact the women declared they preferred working in the shade in the sheds rather than in the sun.
The investigators recommend that a technical enquiry be carried out in order to ascertain the degree of harm-
fulness of the nicotine contained in the atmosphere of the sheds. They also intimated that it would be useful if a medical investigation were under-
taken into the length of time worked by the boys who help to heap up the tobacco, and of the effect on the women and girls who work in the sheds of their bent posture. In several sheds the investigators found children of four and even younger, who had come with their mothers, and were trying to unfold tobacco leaves; they therefore state that they consider the presence of any child under twelve years of age should be prohibited if it is medically demonstrated that there is danger therefrom for the child. In such cases, there should be on the premises near the shed where the sorting is done, a place reserved for children, who should be placed under the care of a person paid by the firm.

The acute form of poisoning occurs particularly among those persons who for the first time take up work on tobacco. It occurs in a transitory form which, however, depends on the capacity of the individual to become accustomed to the injurious influence of the surroundings.

According to some rather old observa-
tions made by Kostial, 72 out of 100 newly engaged cigar makers, girls between twelve and sixteen years of age, became ill during the first six months. The disorders under observation were diagnosed as follows: cerebral congestion, nervousness, precordial pains, palpitation, anaemia, gastritis, enteritis, conjunctivitis, lassitude, feverishness, insomnia, cold sweats and anorexia. But Ygonin considered these disorders to be of unusual occurrence.

Other experts have reported headache, giddiness, a sensation of throat con-
striction, nausea, vomiting, conjunctival irritation and watering of the eyes. Legge has reported a fatal case — that of a workman employed in "steeping" the tobacco; he apparently developed an acute attack of nicotine poisoning. Cases of acute poisoning have also been described among vine growers who had used nicotine for disinfecting the plants.

Lockhart, of Nottingham, is quoted by Bridge as describing in 1890 a case of acute poisoning in a woman who, whilst carrying a wooden jug of concen-
trated nicotine, upset a little on her sleeve (about 00 grm.). Although she immediately turned up the sleeve and washed the skin with warm water, yet thirty minutes later she suddenly collapsed. Emergency measures with artificial respiration were employed. She was incapacitated for several days.

The nurse who looked after her and had touched the dress stained with
nicotine was also affected, though slightly. Quite possibly absorption of the alcoloid through the skin was helped by cleansing the skin with warm water. Overton in 1930 examined five women employed in packing fumigation paper saturated in nicotine. The women wore masks, but two complained, before using the protecting apparatus, of troubles due to dust from the paper. Overton stated that both women were suffering from pellagra.

There is general agreement in the opinions held with respect to acute poisoning; but there is great divergence of opinion among experts in respect to chronic poisoning.

Very divergent results from enquiries carried out in the factories of several countries are on record. According to Allevi, these negative results do not exclude the possibility of a chronic occupational tobacco poisoning. They only prove the non-existence of such a toxic condition among the factory workers examined, which is quite a different thing. In order to exclude the possibility of occupational poisoning, it would be necessary to cancel all the observations and research carried out up to our times which point to the contrary. Since this is not possible, it becomes essential to find some explanation which helps to reconcile apparently irreconcilable facts, in other words to make seemingly contradictory results agree.

While refraining from the acceptance of certain opinions that are somewhat exaggerated, Allevi does admit that there is such a thing as chronic poisoning by tobacco. The negative results emphasise the fact that tobacco poisoning, like many other occupational diseases, is tending to disappear, thanks to continuous advance in industrial technique and hygiene. As a matter of fact, the favourable results of the greater part of the enquiries come from countries where tobacco is a monopoly, whereas less favourable come from those countries where the industry is free, and carried on either at home or in small factories, e.g. in Great Britain, where, according to Giglioli in 1906, the sanitary conditions were good in the large factories, whereas in the small factories many of the women complained of persistent headache, nausea, general debility, and menstruation troubles; while the number of miscarriages reached 60 per cent., which is very high.

A rapid summary of the special pathology of tobacco workers gives the following facts:

Among native workers employed on the tobacco plantations, e.g. in Sumatra, ulcers on the legs have been observed, and also a fairly high incidence of cases of ankylostomiasis. The coolies of Northern Borneo know very well that in the course of preparing the soil for the planting they are exposed to a risk of contracting dermatitis, caused by contact with the Anacardiacae and in particular with the Rhus and the Rhus.

In the factories the workers suffer from dermatitis due to contact with the leaves, the dust or the juice from the tobacco. The lesion is situated generally on the back of the hands, but may affect the face, the back and other parts of the body, and, in particular, the genital organs, where the dust and juice may be conveyed by unwashed hands (Davis, Karrman). Sensitisation tests with nicotine have proved that an allergic condition can undoubtedly be established.

Besides these cases of dermatitis, other forms have been noted which are persistent and recurrent (Roth, Stephani), especially among cigar-makers (United States, 1916), caused by the glue used for sticking the cigar covering, or by olive oil used for the manufacture of roll or plug tobacco (Collis). In these last cases, numbering 27, the lesion was situated especially on the back of the left hand. The persons affected are those employed in the selection of the finest leaves (picking) or in stemming, for removal of the nerver of the leaves, or in taking to pieces the tobacco milis, called "maces" after the fermentation, or in grinding or sifting snuff. Overton in 1929 often came across cases of dermatitis among workers employed in stemming, and stated that the use of tools, which diminished manual labour, seems to reduce the frequency of these affections.

Damage to the nails of one or two fingers has also been observed on one or both hands. Listengarten in 1930 wrote that the free edge of the nail becomes thin; the nail comes off and a very painful hyperkeratosis follows, caused by the dust. The worker is obliged to stay away from work. The nail grows again, but as a rule the resumption of work, at the end of a fortnight, causes the nail to come off again. According to this authority, the lesion is due to a chemical rather than a mechanical agency.

Cases of gingivitis, acute and chronic, and of stomatitis have been reported among tobacco workers by Fischer. Of 158 persons who were examined only
35 had a normal buccal mucous membrane.

Catarh of the respiratory tract, inactive tuberculosis, but no cases of pneumoconiosis, were described by Kruger, Rostoski and Saupe in 1928; cases of bronchitis were reported by Allevi, Rosenfeld and Pirnet; cases of pulmonary congestion by Lavagna; and also cases of asthma.

At the autopsy on two women workers, Zenker observed brownish patches on the pulmonary parenchyma and on the hilum glands as well as very marked atrophy of the lungs. He attributed these lesions to the action of tobacco, and described them under the name of "tobaccosis".

Whilst Landis, Funk, Smyth and Miller do not admit injuries of the respiratory apparatus caused by tobacco, basing their opinion on the results of an enquiry made in Philadelphia factories, Landis in 1920 acknowledged that there is a certain amount of tobacco dust in the air of the workshops, but states that the clinical and radioscopic examinations of the people employed are such that all question of pulmonary lesion may be excluded.

In 1921 Palitzsch resumed the study of pneumoconiosis caused by tobacco, and feels justified in concluding, according to his clinical and radioscopic observations, that this "tobaccosis" resembles very closely anthracosis, in the peculiarity of having the lesions at the back of the eye caused by tobacco; Dowling in 1892 reported a case of bronchitis, some years after the individual had worked at a tobacco factory, and described them under the name of "tobaccosis".Whilst Landis, Funk, Smyth and Miller do not admit injuries of the respiratory apparatus caused by tobacco, basing their opinion on the results of an enquiry made in Philadelphia factories, Landis in 1920 acknowledged that there is a certain amount of tobacco dust in the air of the workshops, but states that the clinical and radioscopic examinations of the people employed are such that all question of pulmonary lesion may be excluded.

Disorders of the digestive organs are reported by Kruger, Rostoski, Saupe, Allevi and Rosenfeld, and appear to be rather frequent. Experimental facts (Adler, Josué, Boveri, etc.) and statistics prove the incidence of such arterial lesions as endarteritis.

The toxic elements of tobacco, and in particular nicotine, seem to settle on the nervous tissue (Guillain and Gy), which would explain the disorders mentioned, and certain local manifestations, such as optic neuritis, as well as cases described under the name of "hysteria" due to tobacco (Gilbert). Peri reported that nervous disorders were frequent among women who worked in an Italian factory, especially during the catamenial periods; and Neiding has noted the same among women workers at Odessa. This authority also considers that nicotine has an injurious effect on the internal secretory glands, and in particular on the thyroid gland.

Most of these experts hold that in the case of these women workers a greater number of disorders of the sexual system is observed than among the general population. In an Austrian report of 1893, Hirsch, Stephani and others affirm that tobacco causes marked sexual excitation. But diseases of the genital apparatus are fairly frequent among the women workers of the factories, and it is chiefly to the repercussion in which these lesions involve the organism, rather than to tobacco itself, that Carozzi attributes the clinical picture known under the name of "chronic tobacco poisoning" among cigarette makers who visit the Industrial Clinic at Milan.

Tobacco dust causes marked irritation of the eyelids and conjunctiva, and causes, especially among beginners, lachrymation and a sensation of burning in the eyes. In the Celli report, cases of conjunctivitis and keratitis stood at figures of 1.58 per 100 sick persons and 0.96 per 100 workers respectively.

Legge has also reported two cases of amblyopia, and several cases of occupational origin are mentioned in medical literature.

Galezowski and Ely in 1897 reported lesions at the back of the eye caused by tobacco; Dowling in 1892 reported a case of amblyopia in a woman who had worked for five or six years and did not smoke; this expert collected facts about 25 cases, observed among 203 workers, of whom 23 were men and moderate smokers, and 2 women who did not smoke at all; De Schweinitz in 1896 observed a case affecting a woman who did not smoke and had worked on tobacco for several years. In Cincinnati factories, Dowling observed disorders of the eyesight, with reduction in visual acuity and confusion of colours in the central vision, attaining a frequency of 5 per cent. But he considered that these disorders were not of occupational origin, as women who did not smoke were not affected.

**Hygiene**

The workshops should satisfy all the standards required by hygiene, with strict cleanliness and the removal of dust as far as possible. The industrial technique should be based on the adoption of mechanical methods to an ever increasing extent; and machines should be supplied with apparatus for
carrying away dust and disposing of it. Thus in the Italian factories from 70-80 per cent. of tobacco dust is successfully removed.

Good ventilation should be ensured and also adequate heating of the workshops.

Every possible measure should be adopted which limits as far as possible contact with tobacco in the form of dust, juice or liquid fumes from the maceration. These measures are more particularly essential in certain departments, e.g. drying, stemming, maturation of the cigars, and the manufacture of snuff.

Further, the fermentation premises should be separated from those where other operations are carried on; and women and young persons should be excluded. Steps should also be taken to ensure the complete isolation of workshops where the leaves are dried and the maturation of cigars is carried on.

Fig. 155. — Type of crèche provided in an Italian tobacco factory.


Measures of personal hygiene, such as lavatories and douche-baths, and working overalls and lead coverings for the women should be provided. Where possible well-managed canteens should be erected for workers who cannot go home for meals.

Strict medical examination should be instituted when signing on, and renewed periodically. As the labour is generally supplied by women, it is advisable to institute a welfare organisation to watch carefully over the health of the women, especially if they are pregnant or have families. It is advisable for pregnant women to quit work during the last months of their pregnancy, and not to return under four or six weeks after the confinement. Facilities should be provided for nursing infants by establishing or developing crèches and special rooms for nursing the babies; installations of this type have for some time past proved their great usefulness in several countries, e.g. in France and Italy (see fig. 155).

LEGISLATION

The employment of women is forbidden in drying shops in Switzerland, and in the Argentine in workshops where the bales of tobacco are opened and where dust is liberated. The employment of boys under fifteen is forbidden in the United States (Delaware) on stemming and sorting; in Poland in tobacco factories under sixteen years; in the United States, on sorting, manufacture and packing and sometimes on stemming (Alabama, California, Kentucky, New Jersey, Massachusetts, Ohio and Pennsylvania); in warehouses, manufacture of cigars and in workshops where tobacco is prepared (Arizona, Nevada and Wisconsin); in France in workshops where the "maces" are taken to pieces; the employment of children under fifteen in Italy on opening of bales, sorting leaves that have not been moistened, and on fermentation; transport of fermented products, drying in closed workshops, crushing, sifting, manufacture of extracts and cutting; under sixteen in Greece and in Spain.

Women under eighteen are not allowed to work in tobacco factories in Greece; the employment of women under twenty-one is forbidden in Spain and Italy on those operations enumerated for boys in the countries in question. Special legislation for tobacco factories exists in Germany (17 February 1917; the Regulations of 17 November 1913 deal with domestic work on tobacco; in Prussia, a Ministerial Decree of 19 February 1929 provides protection for persons employed on certain operations in the manufacture of cigars); in Denmark (Decree of 1 June 1904, amended 31 October 1906); in Estonia (Decree of 1925); in Egypt (14 Au-
Almost insoluble in water, it mixes with alcohol, ether and sulphide of carbon. It dissolves sulphur, phosphorus, iodine and, especially, in very large quantity, fats and resins. When set on fire, it burns with a flame which produces much soot.

Toluene constitutes 10-25 per cent. of crude benzenes. It is formed by the dry distillation of balsam of Tolu, of various resins and by the distillation of tar. It is extracted also by distillation from mineral oils, from oils of coal tar and lignite when subjected to a high temperature. When solvent naphtha is submitted to the process of "cracking", or partial breaking down, it liberates large quantities of toluene in the presence of Blau gas. It is obtained industrially in large quantities as a by-product from coal tar, in cokers and gas works (see article "Gas Works").

Crude toluene is purified from the carbohydrates of the fatty series, such as olefinic and paraffinic hydrocarbons, which always accompany it, by washing it with hot sulphuric acid, to which has been added a little nitric acid. It can also be purified by heating with metallic sodium.

Commercial toluene distils to a 99 per cent. purity below 112° C. It is chiefly used as a solvent mixed with benzene. It is used in the manufacture of pharmaceutical products, perfumes, intermediary products of colouring materials, and in the manufacture of its derivatives and other products, such as benzaaldehyde, benzoic acid and saccharine.

Large quantities of toluene are nitrated and used chiefly in the form of trinitrotoluene (see that article).

Among the derivatives of toluene the following should be mentioned in particular:

**Nitrotoluene**: ortho-, meta- and para-nitrotoluene (C₆H₄(CH₃)NO₂) and the dinitrotoluenes (C₆H₄(CH₃)₂(NO₂)). As regards these derivatives, see the article "Nitrobenzene".

**Halogen derivatives**: The following are the most important: benzyl chloride (C₆H₅CH₂Cl), benzyldene chloride (C₆H₅CHCl₂) and the chlorides of benzene or phenylchloroform; and benzene trichloride. They are fluids with a strong aromatic odour; they cause in experiments on animals violent manifestations of irritation after exposure lasting for several hours.

**Amine derivatives**: The most important are represented by the ortho-, meta- and para-toluidines, homologues of aniline, which are obtained
by reduction of the corresponding nitrated derivatives.

As in the nitration of toluene, three similar isomeres are obtained; by their reduction a mixture of the three aminated derivatives is obtained, which can be split up by allowing it to fall into a solution of oxalic acid, in the presence of hydrochloric acid, kept at boiling point. The oxalate of para-toluidine then separates, and the liquid filtrate contains the soluble chlorohydrates of the two other toluidines.

The ortho-isomere, \((\text{C}_6\text{H}_5\text{CH}_2\text{NH}_2\text{Cl})\), is fluid: the para-solid, in the form of scales; they volatilise with steam. Their toxic effect is analogous to, and, according to some authorities, even stronger than, that of aniline. The clinical picture resembles that of anilism; however, cyanosis is less frequent, while from the beginning severe headaches are quite common.

A feeling of heat situated on the face is a characteristic and early symptom. Several authorities consider that while, generally speaking, the toxic effect of toluidine is similar to that of aniline, the latter is liquid and the former solid (Hamilton). The three isomeres destroy the red blood corpuscles and lower the temperature. The meta-isomere is not used in industry; the para-isomer is more toxic than the ortho-, although the latter is liquid and the former solid (Hamilton). The reason why the risk is more serious than with aniline lies in the fact that, when centrifuging the two toluidines, workmen are exposed to both the action of fumes and to contact with the products. Several serious cases are recorded in literature, by Friedlaender in 1900, and Stark in 1892, with coma, delirium and prostration, from simple contact of the skin with toluidines.

Persons who are employed in the manufacture of aniline colours and explosives, due to inhalation of toluidine fumes, are particularly exposed to the risk of poisoning.

**Chloro-toluidine** \((\text{C}_6\text{H}_5\text{CH}_2\text{NH}_2\text{Cl})\), which is obtained by reduction of the corresponding chloro-nitrotoluene, is liquid and volatilises very rapidly at the ordinary temperature \((18-22^\circ\text{C})\).

It is used in the preparation of some of the aniline colours. Having regard to the extreme facility with which it volatilises at ordinary temperatures, risk of poisoning by its inhalation is unexpectedly small. As a matter of fact, inhalation of fumes of chloro-toluidine, continued experimentally for from ten to twenty-one days, has not caused any definite signs of poisoning in animals. On the other hand, its application to the skin gives rise to a pronounced haemolytic reaction.

No case of industrial origin is known (Hessbruggen, 1928); but some authorities suspect this product to have been the cause of cancer of the bladder among workmen who had handled it.

In Great Britain, in 1930, 10 cases of poisoning by inhalation of the 5 ortho-chloro-toluidine were reported. From the commencement of work the workmen were affected with slight headache, somnolence, and irritation of the nasal and conjunctival mucous membranes. Later, strangury was reported, followed by haematuria.

The rarity of this poisoning being accepted, an investigation undertaken by the Industrial Hygiene Service of the International Labour Office has made it possible to present the following facts. No case has been observed up to the present in Germany, and the question has been submitted to a conference of factory medical officers in the chemical industry. In Switzerland, one case was reported in 1928, in a workman who had received a jet of chloro-toluidine on the lips; he suffered from haematuria, albuminuria, strangury and necrosing cystitis. Apparent recovery had occurred at the end of a month; but six months later there was a return of the cystitis; and work could not be resumed until two months later. In the United States, no case of poisoning has been observed in a factory which prepares the product in question on a large scale, up to several thousand pounds a month. The manager of this factory thinks that this can be attributed to the fact that 5 ortho-chloro-toluidine is used in the form of the sulphate or chloride, the toxicity being thus reduced.

The para-isomere is the commonest of the toluyldiamines; it is obtained by reducing the corresponding dinitrotoluene with iron, together with hydrochloric acid (see article "Paraphenylendiamine"), and is chiefly used in the manufacture of such colouring materials as Safranine T. It is often mixed with paraphenylendiamine. Poisoning may occur from the inhalation of fumes or dust. It is a blood poison with haemolytic action; it forms methaemoglobin, and is also a poison to the hepatic cell. It is said to be less toxic than toluidine.

Next should be mentioned aminoazetolubine, a derivative of ortho-toluidine, used in the preparation of alizarine.
Two cases of poisoning are known, which were characterised by cyanosis, headaches, a slight rise of temperature, pulse rate, and albuminuria. These were cases in which aminoazo-benzene, or scarlet red, had been applied locally on broken skin.

The toxic action of toluene is analogous to that of benzene, although experiments on animals have proved that it is a little more toxic; according to Lehmann commercial toluene is two-fifths more toxic. Narcosis comes on sooner than with benzene (Lehmann), whilst the other symptoms appear more slowly. Kober and Pugliesi, on the other hand, are of the opinion that the toxicity of toluene is less than that of benzene, although it shows a stronger irritant action on the mucous membranes. It has less tendency to produce convulsions than has benzene. Recovery from the effects of toluene is slower than in the case of poisoning by benzene.

Rambousek, using a solution of 10-12 mg. per litre, found that rats at the end of two hours lay on their side, and died if the strength of toluene was carried to 30-35 mg. per litre. In the case of a pure product, 30 mg. per litre causes profound narcosis; with 40-45 mg. at the end of fifteen minutes the animals stagger and become paralytic. Batchelor, in 1927, found that 6 mg. per litre causes in man irritation of the mucous membranes, slight nervous disorders and somnolence.

It is only at high concentrations of toluene and xylene that there occurs a moderate diminution in the number of red blood corpuscles, and of haemoglobin, with, generally, strong leucytosis. Hektoen, on the other hand, has not obtained with toluene the changes in leucocytes which are caused by benzene: neither immediate changes in the number, nor in the formula, nor in the phagocytic activity of the leucocytes. Nor did he find any change in the sedimentation or in the resistance of the red blood corpuscles. In conclusion, the action of toluene and xylene on the blood may perhaps be regarded as less serious than that of benzene.

In chronic experimental poisoning by toluene the symptoms are also less characteristic than in poisoning by benzene (Hektoen, Brown). With animals, repeated injections of toluene have caused hyperplasia of the myelocytes of the bone marrow and phagocytosis of the leucocytes by the giant cells, without any concomitant increase in the blood cells or changes in the liver or spleen (Brown).

In Great Britain, 2 cases of poisoning were reported in 1919; but it should be said that many of the cases are included under the heading "poisoning by aniline". As a matter of fact, from 1925 — the date at which notification of cases of poisoning by nitro- and amino-derivatives became compulsory — to 1930, 193 cases had come to notice; of these, 66 were due to dinitrobenzene, dinitrotoluene and trinitrotoluene; 11 to toluidine; and 10, in 1930, to chloro-ortho-toluidine.

An investigation in 1929 by Overton in factories making artificial leather has shown once again that, generally speaking, this material is not a single product, but a mixture of several organic substances, for example, benzene, 84 per cent.; toluene, 13 per cent.; and xylene, 3 per cent.; as well as traces in varying quantity of acetone, and methyl alcohol, etc. Commercial toluene is most often composed of benzene, 15 per cent.; xylene, 5 per cent.; and toluene, 80 per cent.; but its constitution varies according to its use. According to Overton, this mixture causes among workers affections which resemble very closely those due to benzene.

Cases of poisoning by toluidine, in addition to those reported in Great Britain, have been observed in Germany, as well as others due to chloro-toluidine, and in one case to its chlorohydrate. The symptoms are similar to those of anilism: cyanosis, headache, haematuria, icterus, leucocytosis, lymphopenia, cramps and coma (Friedlaender, Stark).

Cases of sub-acute poisoning, among workers preparing a flypaper paste, due to toluidine have been reported by Rosenthal-Deussen in 1930. In addition to the symptoms enumerated above, the patients presented characteristic haematological lesions, without apparent change in the haemoglobin or the red blood cells; but, on the other hand, there was a marked diminution in neutrophiles, with deviation to the left, and a great increase in the eosinophiles.

In Germany, cases of chronic poisoning have been reported, following upon the handling of toluene either as a solvent or for cleaning purposes. One case of poisoning was caused by the sulphonchloride of toluene.

In Austria, Adler-Herzmark and Selinger in 1931 examined the workers in various Viennese factories wherein are handled products containing benzene, toluene and xylene. In a group of 48 workers, 10 of whom were women, employed in painting
large articles with a spray, it was found that the blood formula was changed in 35, 4 of whom were women, aged twenty-five years or less. In addition, the workers complained of cephalalgia, vertigo, nausea, cough and irritation of the pharynx. The objective symptoms noticed were: pallor, 9 times; pharyngitis, 24; trembling, 11; exaggeration of reflexes, 16; and goitre, 5.

In a group of 56 workers, 36 of whom were women, employed in painting small articles with a spray, alterations in the blood formula were found in 42, 27 of whom were women. The workers complained of the same affections as those of the first group. A worker employed at a factory for pharmaceutical products in dissolving certain substances in pure benzene showed only a slight trembling, whilst one of his comrades complained of burning in the eyes, cough and vertigo, and exhibited conjunctivitis, pharyngitis, pallor and exaggerated reflexes. In both cases there was alteration in the blood.

In a last group, comprising 33 workers, 6 of whom were women, the blood formula was changed in 27 workers, 5 of whom were women. Nearly half of those examined did not make subjective complaints. Among the others, there were present cephalalgias, vertigo, gastric disorders, and a state of ebriety and confusion.

As regards cases of poisoning by toluol, benzol and xylol among workers employed in heliography work, see article "Printing Trades".

Since the case reported in 1911— which was due to the inhalation of the fumes of meta-toluyldiamine, and was characterised by violent headaches, vomiting and jaundice, with death from cardiac failure, while at the autopsy acute yellow atrophy of the liver was found — the toxic effect of this substance has been made the object of researches by Arrak, who drew attention in 1927 to polyglobulins; by Shyogo Hosoya, who in 1927-1928 studied jaundice due to toluylendiamine; by Stadelmann, Dragendorff and Pick in 1909; and by Kaneyoshi Miha in 1925.

As regards measures of hygiene and treatment, see articles "Benzene Derivatives", "Nitro and Amino Derivatives", etc.

Dr. R. Fischer (Berlin).

Tortoiseshell (Turtleshell)


Under this name is known industrially the horny plate constituting the shell of certain kinds of sea tortoises of the genus Chelonia.

Commercially several kinds of tortoiseshell are designated according to their thickness, colour and transparency, varying according to the kind of animal and the part of the shell (upper or lower). The light shells, the thickest and the most transparent are those most sought after.

Tortoiseshell consists of a horny substance appearing under the microscope in the form of oblong regular translucent or opaque cells with a yellow ground more or less stained and veined reddish brown, at times an almost uniform brown colour.

Tortoiseshell is used in the manufacture of small objects such as fans, knife handles, handles for lorgnettes and eye glasses, small stationery goods, combs, brush backs, snuff boxes and cigar and cigarette cases.

Tortoiseshell is worked like horn (see that article). It is softened by a hot process, pressed, agglomerated, moulded, sawn, cut into sheets for manufacture of fancy goods, cut out and polished. The bits of waste left over can be soldered by means of pressure at a high temperature and furnish a composite tortoiseshell lacking the colour and transparency of natural tortoiseshell. There should also be mentioned imitation tortoiseshell made from celluloid, gelatine mixtures, bone meal, galalith, bakelite and other similar products, or again from horns steeped in vinegar and then placed in alum, and dyed.

The manufacture of snuff boxes and cigar and cigarette cases involves, among others, the operations of dressing and mounting. The side pieces are cut out and placed on a frame or a wooden mould. After hinges have been added, the operations of fitting and putting on the lid are proceeded with; finally, the article is engraved, decorated and polished.

The sources of risk are similar to those due to horn (see that article), especially during polishing (dust), together with the effects of products applied during the various operations. There is no risk from infectious diseases.

For artificial tortoiseshell the danger is connected with the various products utilised (see corresponding articles).
For hygienic precautions to be taken, see article "Horn".

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Transport Industry

(a) Railways, Tramways, etc.

French: Chemins de fer, tramways, etc. — German: Eisenbahnen, Straßenbahnen, usw. — Italian: Ferrovie, tranvie, etc. — Spanish: Ferrocarriles, tranvías, etc.

Means of transport by road and rail have rapidly extended since the second half of last century. Motor transport now tends to exceed in development all other means.

The entire number of persons occupied is continually increasing, especially as numerous undertakings effecting accessory work continue to increase the personnel exclusively engaged in transport.

Railways

The staff of railway systems is everywhere very numerous: Germany (1930), 700,000; Great Britain (1930), 700,000; Italy (1929), 150,043; United States (1930), nearly 1,700,000. The term "railway staff" includes groups of individuals exercising widely different operations, so that the factors effecting injury to the persons involved are very numerous. The 150,043 Italian employees include, among others:

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clerical staff</td>
<td>16,557</td>
</tr>
<tr>
<td>Station-masters, agents, etc.</td>
<td>15,956</td>
</tr>
<tr>
<td>Station employees 1</td>
<td>49,785</td>
</tr>
<tr>
<td>Locomotive men (engine-drivers and firemen)</td>
<td>13,613</td>
</tr>
<tr>
<td>Railway guards</td>
<td>17,540</td>
</tr>
<tr>
<td>Men at work on permanent way</td>
<td>20,199</td>
</tr>
<tr>
<td>Men working in railway shops</td>
<td>20,679</td>
</tr>
</tbody>
</table>

1 The expression Stations: Personnel de fatigue (French) or Stazioni: Personale di fatica (Italian) has been rendered in English by the words "station employees" throughout the text. It covers all manual workers engaged in the station and excludes clerical staff.

For obvious reasons reference will not be made in this article to the clerical staff or workers in the railway workshops.

As to the remainder of the staff, those employed on the permanent way must be included, the work done being comparable to that of navvies and the workers being continuously exposed to atmospheric influences and to the varying conditions under which the work has to be done (muscular effort).

Risk incurred by station-masters, agents, etc., whose business it is to look after the trains, is represented by standing about in the open air (atmospheric conditions), brusque changes in the temperature (frequent going in and out of offices), etc. The same causes also affect pointsmen, shunters, etc.

The last two categories have often to do night work. But in general the work of the pointsmen and shunters is not very different from that of the line superintendents.

The signal-box staff at important stations is subjected to much nervous strain due to the intensity and duration of the work, as well as to the intense muscular effort (manipulating the signals).

Specific railway work is that confided to the locomotive men and guards. The factors which it is necessary to take into account are the following: irregularity of hours of work, long journeys constantly recurring, irregular meals—generally far from home, and sometimes cold—sleep taken on the journey, rarely at home. In the case of the engine-drivers there must be added the brusque changes of temperature (great heat radiated from the furnace and external cold), shocks and vibration, draughts, noises, etc., etc. Great differences of temperature exist in the cabin itself (nearly 40°C, for example, between the floor and the level of the head), according to place and time (Variscey, 1957). While going through tunnels there is the possibility of poisoning by carbon monoxide and by other products such as sulphur dioxide from coal with a high sulphur content. There must also be taken into account the prolonged nervous tension for the engine-driver when the going is difficult, and the intense muscular effort of the fireman (in stoking the coal).

The task of carriage cleaner does not seem to be particularly unhealthy. Van Themsche did not find a higher amount of respiratory illness than that to be met with in any dusty trade, nor was there a higher rate of illness attributable to using solutions and disinfectants. But it is advisable that only persons with absolutely sound lungs should be admitted to this occupation.

The influence of these various elements on the state of health of the workers can only be elucidated by an examination of the morbidity data, the diminution in capacity for work, and the mortality data, as furnished by the railway companies. In this study there has been taken especially into account the statistics of the Italian railways as recorded since 1880 by one of the largest companies (that of the Adriatic) and continued since the unification of the principal railways of the State.
For the period 1886-1892 on the Adriatic Railway the general morbidity figure was 110 for 100 persons; the number of days lost 10.9 for each case of sickness, and 11.6 per person.

It should not be forgotten that in the statistics of the Italian and French (P.L.M.) railways cases of sickness are computed from the first day of absence, and that, on the other hand, statistics of industrial morbidity relate in general to cases having a duration of incapacity exceeding a week (waiting period). Thus all the slight cases are eliminated, which undoubtedly constitute the majority (nearly 73 per cent.) on Italian railways according to an approximate calculation made by Filippini. In column 3 of Table I, morbidity is calculated only for cases lasting over a week.

Even when submitted to this elimination the morbidity figures for the railway employees are still generally so much higher than those of other classes of workers as not to be of use for comparison. These differences must depend on various causes, among others on the manner in which the statistics are prepared. Moreover, the epidemics which attack the rest of the population also affect railway staffs (e.g. pandemia of influenza in 1919). Other elements contribute to alter the morbidity curve; for example, the con-

cessation made in 1909 to Italian railway-men to pay full wages from the first day of illness (instead of two-thirds as previously) caused a sudden rise in the cases of sickness without obvious morbidity cause. Likewise, American statistics show that the frequency of cases of long duration (80 days and over) is greater for those workers who receive sickness pay for 52 weeks than among those who receive it only for 13 or 26 weeks (the average duration of cases of sickness in such statistics is from 30 to 58 days).

The occupation may cause morbidity affections obliging the workers to give up their work before the time gener-

### Table I. General Morbidity on Italian Railways

<table>
<thead>
<tr>
<th>Years</th>
<th>Number of cases per 100 employees</th>
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<th>Average duration of each case in days</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1906</td>
<td>113.90</td>
<td>30.70</td>
<td>12.03</td>
<td>13.5</td>
</tr>
<tr>
<td>1913</td>
<td>77.75</td>
<td>21.80</td>
<td>11.06</td>
<td>8.60</td>
</tr>
<tr>
<td>1921</td>
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<td>26.50</td>
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</tr>
<tr>
<td>1925</td>
<td>102.18</td>
<td>27.50</td>
<td>10.09</td>
<td>10.41</td>
</tr>
<tr>
<td>1926</td>
<td>101.30</td>
<td>27.40</td>
<td>10.44</td>
<td>10.56</td>
</tr>
<tr>
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<td>27.30</td>
<td>10.80</td>
<td>10.85</td>
</tr>
<tr>
<td>1928</td>
<td>100.76</td>
<td>27.40</td>
<td>10.90</td>
<td>10.95</td>
</tr>
<tr>
<td>1929</td>
<td>115.05</td>
<td>31.10</td>
<td>10.30</td>
<td>12.61</td>
</tr>
</tbody>
</table>

### Table II. Morbidity in Other Railway Systems

<table>
<thead>
<tr>
<th>Year</th>
<th>Paris-Lyons-Mediterranean Railway</th>
<th>Swiss Federal Railways</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of cases per 100 employees</td>
<td>Number of days of absence per employee</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Sickness</td>
</tr>
<tr>
<td>1922</td>
<td>115.3</td>
<td>106.1</td>
</tr>
<tr>
<td>1923</td>
<td>121.0</td>
<td>106.8</td>
</tr>
<tr>
<td>1924</td>
<td>109.8</td>
<td>94.6</td>
</tr>
<tr>
<td>1925</td>
<td>116.7</td>
<td>100.1</td>
</tr>
</tbody>
</table>

For the period 1896-1902 on the Adriatic Railway the general morbidity figure was 110 for 100 persons; the number of days lost 10.9 for each case of sickness, and 11.6 per person.

It should not be forgotten that in the statistics of the Italian and French (P.L.M.) railways cases of sickness are computed from the first day of absence, and that, on the other hand, statistics of industrial morbidity relate in general to cases having a duration of incapacity exceeding a week (waiting period). Thus all the slight cases are eliminated, which undoubtedly constitute the majority (nearly 73 per cent.) on Italian railways according to an approximate calculation made by Filippini. In column 3 of Table I, morbidity is calculated only for cases lasting over a week.

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<table>
<thead>
<tr>
<th>Year</th>
<th>Paris-Lyons-Mediterranean Railway</th>
<th>Swiss Federal Railways</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of cases per 100 employees</td>
<td>Number of days of absence per employee</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>1922</td>
<td>115.3</td>
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<td>1923</td>
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<td>109.8</td>
<td>94.6</td>
</tr>
<tr>
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<td>116.7</td>
<td>100.1</td>
</tr>
</tbody>
</table>
years of age. These are subjects unsuited to the work and unfit, who, having survived the medical examination, succumb at the first contact with the work and are eliminated. After the period of stabilisation — the working prime so to speak (thirty to forty years) — round about forty-five years the effect of the medical re-examination of the special senses becomes manifest, causing a notable elimination, increased by various effects of wear and tear on the system due to age. The premature elimination reaches its maximum from fifty to fifty-five years.

A similar phenomenon is seen among railwaymen belonging to railways which arrange their statistics by age-groups. Thus, for example, on the Swiss Federal Railways, the morbidity, which amounts to 74.2 per cent. under 50 years, descends to 69.5 for age-group 30-34, to 65.9 for 35-39, to 63.3 for 40-44, to 64.1 for 45-49, to 66.8 for 50-54, and to 78.2 for 55-59.

**Table III. — Increase in Retired Cases According to Age-Groups, Italy, 1925-1928**

<table>
<thead>
<tr>
<th>Age</th>
<th>Total number</th>
<th>Number of cases due to accidents</th>
<th>Number of cases excluding accidents and defects of the special senses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 30</td>
<td>406</td>
<td>81</td>
<td>325</td>
</tr>
<tr>
<td>31-35</td>
<td>364</td>
<td>89</td>
<td>254</td>
</tr>
<tr>
<td>36-40</td>
<td>445</td>
<td>87</td>
<td>358</td>
</tr>
<tr>
<td>41-45</td>
<td>516</td>
<td>70.7</td>
<td>436</td>
</tr>
<tr>
<td>46-50</td>
<td>505</td>
<td>44</td>
<td>461</td>
</tr>
<tr>
<td>51-55</td>
<td>567</td>
<td>20</td>
<td>547</td>
</tr>
</tbody>
</table>

In Germany the morbidity and mortality figures are above the average of those for the rest of the population. That is especially the case for the train staff. They hold first place as regards invalidity, followed by the station employees and the workers on the permanent way (Bogdan).

Besides accidents the causes of incapacity are especially rheumatism, gout and heart diseases. Pulmonary phthisis plays a minor role, especially amongst the clerical staff (Bogdan).

If the morbidity figures for each class are examined the following values are found in Italy for example per 100 persons during the period 1923-1929:

- Workers in workshops: 114.50
- Station shunters: 111.70
- Train staff: 108.10
- Locomotive men: 101.60
- Workers on the permanent way: 94.83
- Stations (employees): 66.76
- Clerical staff: 43.66

The retirements per 1,000 persons during the period 1925-1928 gives the following figures:

<table>
<thead>
<tr>
<th></th>
<th>Total number</th>
<th>Excluding accidents and maladies of the special senses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workers on the permanent way</td>
<td>6.15</td>
<td>3.00</td>
</tr>
<tr>
<td>Station shunters</td>
<td>5.60</td>
<td>3.56</td>
</tr>
<tr>
<td>Locomotive men</td>
<td>5.60</td>
<td>3.40</td>
</tr>
<tr>
<td>Train staff</td>
<td>5.10</td>
<td>3.10</td>
</tr>
<tr>
<td>Workers in workshops</td>
<td>4.98</td>
<td>2.98</td>
</tr>
<tr>
<td>Clerical staff</td>
<td>3.56</td>
<td>2.56</td>
</tr>
<tr>
<td>Stations (employees)</td>
<td>1.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

In Australia the morbidity and mortality of the employees on the railways and tramways of New South Wales (1924) and railways of the State of Victoria (1922-1923 and 1924) have been studied in detail by Robertson and Taylor.

During the period stated the number of days of sickness was 38,371 for New South Wales and 27,384 (annual average) for Victoria. The latter figure includes absences due to sickness and accidents, while the figure for New South Wales includes neither sickness for less than three days nor accidents.

The average number of days of sickness per individual and per year was 3.24 (New South Wales) and 3.85 (Victoria).

Taking account of all causes, including accidents, the number of illnesses was 239.7 per 1,000 (New South Wales) and 419.5 (Victoria); it falls to 215.1 and 207.3 respectively when external causes and absences of less than three days are excluded.

The following table contains a comparative statement of cases of sickness analysed according to cause:

**Table IV. — New South Wales and Victoria**

<table>
<thead>
<tr>
<th>Causes of absence</th>
<th>N.S.W. (1923-1924)</th>
<th>Victoria (1924)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious, epidemic and endemic diseases</td>
<td>62.9</td>
<td>63.1</td>
</tr>
<tr>
<td>Influenza</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Tuberculosis of the respiratory tract</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Various</td>
<td>4.3</td>
<td>7.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>68.4</strong></td>
<td><strong>71.2</strong></td>
</tr>
</tbody>
</table>
Examining the diverse cases of sickness, according to the age of the persons attacked, no conclusions can be drawn as to their particular frequency for a particular period. According to the various months of the year a notable frequency of rheumatism, gout, respiratory disease (winter months) and digestive troubles have been noted during the first three months of the year.

In Switzerland the morbidity of the Federal Railways staff between seventeen and twenty-five years is characterised as follows: the curve for infectious diseases heads the list in each year and for each class. In practice it is chiefly a question of influenza; the other diseases, including tuberculosis, occupy a quite secondary place. In order of importance there follow respiratory diseases. Influenza, it should be noted, has undergone, since 1918, a biennial exacerbation. In 1918 the proportion reached 54.28 per cent. (workshops) and 51.2 (traction). Further, during periods of influenza, the curve of the other maladies has fallen in general. This has been attributed partly to the fact that during the epidemic all affections have been ascribed to influenza. Generally speaking, the morbidity of workshop operatives is greater than that of the train staff. Cases of disease and accidents (1924 and 1925) of the employees and workmen of the Swiss Federal Railways averaged:

<table>
<thead>
<tr>
<th>Disease (total)</th>
<th>Employees</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer</td>
<td>0.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Rheumatism</td>
<td>8.2</td>
<td>16.6</td>
</tr>
<tr>
<td>Anaemia</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Various</td>
<td>1.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>11.2</td>
<td>17.1</td>
</tr>
</tbody>
</table>

In the U.S.S.R., an enquiry (1926) on the morbidity on the Murman Railways covered 24,212 employees (21,139 men and 3,073 women) classifying the workers in the following 7 categories: locomotive men; train staff; permanent-way workers; station staff; ticket office staff, statistics department and counting-house clerks. Diseases of the digestive tract take first place, followed by dermatosis. The locomotive men showed the largest number of diseases; and the workers on the trains a high proportion of venereal diseases, eye affections and tuberculosis; the workers on the permanent way suffered especially from skin diseases, rheumatic affections and bronchitis. Adolescents (fifteen to nineteen years) constitute the age-group most affected by disease.

**Mortality.** — In Italy, the mortality rate passed from 6.30 per 1,000 (1886-1892) to 7.16 (1906-1912) and 2.28 (1921-1928). Only in 1918 did it reach 13 per 1,000 (influenza pandemic). Not only did the other classes of workers show a much higher mortality figure, but even the male population in general from twenty to sixty years (corresponding to the age of the railway workers) showed a figure of 6.9 per 1,000 in 1926, a year of low mortality.

The death rate per cent, in descending order during the period 1921-1928 works out as follows: general diseases: station staff (shunters, pointsmen, etc.) 2.3; train staff, 2.28; locomotive men, 2.16; permanent-way workers, 2.08; clerical staff, 2.04; station staff (clerks), 1.96; workers in the workshops, 1.96. If accidents are taken into consideration, the order is as follows: locomotive men, 0.81; permanent-way workers, 0.78; station staff (shunters, pointsmen, etc.), 0.69; train staff, 0.64; in the workshops, 0.56; station staff (clerks), 0.08; office staff, 0.07.

Such a privileged condition in comparison with other classes of workers is due partly to selection of the work-
ers before admission; it proves also in every way that work on railways does not entail important risks for life and safety.

The principal causes of death are in descending order: respiratory diseases, the consequences of accidents and circulatory diseases.

Of 635 cases of death in Germany reported in 1913-1917 among engine-drivers, accidents accounted for 137, pneumonia for 65, heart disease for 68, diseases of the intestines for 66, tuberculosis for 67, influenza for 44, and cancer for 42.

In Australia the statistics already quoted by D. G. Robertson and G. H. Taylor give the following indications:

<table>
<thead>
<tr>
<th>Group of diseases</th>
<th>Number of deaths per 1,000 cases</th>
<th>Number of deaths per 100,000 employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious, epidemic and endemic diseases</td>
<td>8.9</td>
<td>47</td>
</tr>
<tr>
<td>General maladies, excluding the above</td>
<td>31.2</td>
<td>36</td>
</tr>
<tr>
<td>Nervous system and sense organs</td>
<td>16.4</td>
<td>39</td>
</tr>
<tr>
<td>Circulatory system</td>
<td>10.3</td>
<td>30</td>
</tr>
<tr>
<td>Respiratory system</td>
<td>16.8</td>
<td>36</td>
</tr>
<tr>
<td>Digestive system</td>
<td>7.2</td>
<td>42</td>
</tr>
<tr>
<td>Genito-urinary apparatus (excluding venereal diseases)</td>
<td>39.0</td>
<td>15</td>
</tr>
<tr>
<td>Skin and sub-cutaneous cellular tissue</td>
<td>1.4</td>
<td>15</td>
</tr>
<tr>
<td>Bones and locomotor apparatus</td>
<td>49.5</td>
<td>104</td>
</tr>
<tr>
<td>External causes</td>
<td>43.0</td>
<td>66</td>
</tr>
<tr>
<td>Ill-defined</td>
<td>15.6</td>
<td>372</td>
</tr>
</tbody>
</table>

In the United States the mortality of engine-drivers has undergone, according to the published statistics of the Metropolitan Life Insurance Company, considerable diminution (from 1912 to 1922), especially between the ages of thirty-one and fifty-five years. Over fifty-five years the indications are not convincing as the number of persons exposed to risk is so reduced. The most considerable diminution was observed in regard to fatal accidents, which, from 318 per 10,000 (1912), fell to 167 (1922), thanks to the improvement in safety precautions for the persons employed. It explains also, in great part, the considerable diminution in mortality for the age group 31-55 years. Similarly, the death rate from typhoid fever fell from 29 per 10,000 (1912) to 2 (1922), and that of tuberculosis from 55 to 40. Increases in mortality are attributable to diseases characteristic of middle and advanced life (heart affections, which caused a death rate of 74 per cent, greater in 1922 than in 1912; cerebral haemorrhage and apoplexy, 11.4 in 1922 more than in 1912; causes which, on the other hand, have shown a marked diminution in the general male population).

In France the average for the decennial period 1913-1922 was, for the Paris-Lyons-Mediterranean Railway, 0.98, with a maximum of 14 per 1,000 in 1912 (influenza pandemic).

According to English statistics for the years 1921-1923, railway officials show a comparative mortality figure of 679 — with a lower mortality than the average over twenty years of age, except for diabetes and appendicitis.

Other railway workers also show a low death rate with the exception of porters. For signalmen the figure is even lower than that of railway officials; for the pointsmen the high death rate is mainly due to accidents.

The causes showing excessive death rates are: for engine-drivers, diabetes and peptic ulcer; for guards, influenza, diabetes and cerebral haemorrhage; for pointsmen, syphilis, cancer of the stomach, cerebral haemorrhage, valvular disease of the heart, bronchitis and peptic ulcer; for porters and lampmen, tuberculosis and respiratory diseases. Some available comparative mortality figures are as follows:

Total males occupied and retired (20-65 years) 9,704,660
Number of registered deaths (20-65 years) 966,384
Railways employees (20-65 years) 275,258
Number of registered deaths (20-65 years) 5,716
Persons employed in road transport (20-65 years) 459,415
Number of registered deaths 12,383

In taking 1,000 as the figure for deaths from all causes for all occupied and retired males between twenty and sixty-five years of age, the mortality rate of railwaymen from different causes works out as follows:
In Switzerland the mortality rate for the period 1917-1928 varied from 4.1 to 4.7 per 1,000, attaining in 1918 only the figure 14.4 (influenza pandemic).

**Pathology**

Analysis of the morbidity, mortality and incapacity for work curves, prepared from the figures just quoted, shows that they are not parallel. Certain categories occupying the first place as regards morbidity rank only second in regard to mortality and pension. In general, engine-drivers and guards on trains show a high morbidity rate. That of the workshop staff is still higher, tending to show that specific railway work exposes to less risk than that of workmen in general. This morbidity, however, has no effect on the general health of the shop workers who come last in regard to incapacity (Italy, Switzerland).

On the other hand, the station employees, then those on the trains, and lastly the locomotive men appear to be those most liable to contract illnesses exerting an effect on their general health. The workers employed on the permanent way also show a low morbidity.

In Italy, diseases of the digestive tract stand highest up to the end of 1918 (influenza pandemic) and after that they are exceeded by rheumatic affections. Digestive trouble is found amongst the train staff (530 per 1,000) and locomotive men (503): the general incidence is 325 per 1,000. In Germany and Switzerland also the same classes furnish a high rate for these maladies. But they have not grave consequences as causes of retirement (0.10 per 1,000), nor do they seriously affect the death rate. This high incidence is explained by irregularity in hours of work, necessity for meals to be taken away from home, by the frequent recourse to cold drinks when perspiring, alcoholic habits, brusque vibration, etc.

Under the term *rheumatism* are included influenza, acute articular *rheumatism* and rheumatic fevers, etc. The various proportions in which these three forms occur are respectively 140, 7.56 and 117 for the year 1928; and 257, 5.8 and 145 for the year 1919 (Italy).

Together with diseases of the digestive tract, rheumatic affections represent the half and even two-thirds of all cases of sickness. The causes are obvious in the case of engine-drivers; for the other categories (except shop workers and clerical staff) they are insufficient protection against changes in the weather; for the numerous agents at stations, work executed alternately on the platforms and in offices with brusque changes in temperature. Rheumatic affections which like digestive maladies, are the most frequent diseases also in the rest of the population, are found most frequently amongst engine-drivers (457 per 1,000) and those in charge of the trains (430), the general average being 303.

Respiratory diseases in Italy show a figure of 107 per 1,000; the maximum occurs among train staff (166) and

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**TABLE VI. — COMPARATIVE MORTALITY FIGURES FOR TRANSPORT WORKERS, ENGLAND**

<table>
<thead>
<tr>
<th></th>
<th>All occupied and retired civilian males</th>
<th>Railway officials, station-masters, etc.</th>
<th>Loco-engine drivers, firemen and clerks</th>
<th>Railway guards</th>
<th>Railway signalmen</th>
<th>Shunters, pointmen and level crossing men</th>
<th>Railway porters and lampmen</th>
<th>Drivers of motor vehicles and steam wagons</th>
<th>Tram drivers</th>
<th>Drivers of home-drawn vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total causes</td>
<td>1,000</td>
<td>679</td>
<td>797</td>
<td>782</td>
<td>682</td>
<td>614</td>
<td>1,023</td>
<td>862</td>
<td>875</td>
<td>1,375</td>
</tr>
<tr>
<td>Influenza</td>
<td>36.4</td>
<td>36.4</td>
<td>31.0</td>
<td>40.3</td>
<td>37.1</td>
<td>27.8</td>
<td>45.8</td>
<td>25.2</td>
<td>55.1</td>
<td>46.3</td>
</tr>
<tr>
<td>Tuberculosis (all forms)</td>
<td>177.3</td>
<td>82.6</td>
<td>107.4</td>
<td>85.2</td>
<td>82.0</td>
<td>108.3</td>
<td>197.6</td>
<td>139.1</td>
<td>165.4</td>
<td>232.1</td>
</tr>
<tr>
<td>Syphilis, etc.</td>
<td>27.1</td>
<td>5.8</td>
<td>23.1</td>
<td>18.7</td>
<td>16.6</td>
<td>30.6</td>
<td>34.0</td>
<td>31.5</td>
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<tr>
<td>Cancer</td>
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<td>103.3</td>
<td>111.9</td>
<td>109.0</td>
<td>84.4</td>
<td>111.0</td>
<td>128.8</td>
<td>126.6</td>
<td>112.4</td>
<td>163.9</td>
</tr>
<tr>
<td>Diabetes</td>
<td>12.2</td>
<td>15.5</td>
<td>16.3</td>
<td>11.1</td>
<td>17.3</td>
<td>11.5</td>
<td>14.8</td>
<td>10.7</td>
<td>11.0</td>
<td>12.3</td>
</tr>
<tr>
<td>Cerebral haemorrhage, etc.</td>
<td>44.9</td>
<td>39.1</td>
<td>44.5</td>
<td>39.7</td>
<td>47.7</td>
<td>49.7</td>
<td>45.7</td>
<td>27.3</td>
<td>12.5</td>
<td>59.1</td>
</tr>
<tr>
<td>Diseases of the circulatory system</td>
<td>152.2</td>
<td>120.9</td>
<td>114.9</td>
<td>110.5</td>
<td>98.7</td>
<td>120.8</td>
<td>199.8</td>
<td>136.9</td>
<td>153.9</td>
<td>202.1</td>
</tr>
<tr>
<td>Gaspoisoning</td>
<td>151.7</td>
<td>69.9</td>
<td>101.5</td>
<td>108.3</td>
<td>56.4</td>
<td>128.0</td>
<td>157.6</td>
<td>131.7</td>
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<tr>
<td>Diseases of the digestive system</td>
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<td>59.7</td>
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<td>38.8</td>
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<td>Suicides</td>
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<td>14.7</td>
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<tr>
<td>Accidents</td>
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<td>56.4</td>
<td>52.9</td>
<td>72.8</td>
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<td>104.0</td>
<td>32.5</td>
<td>42.3</td>
<td>12.8</td>
<td>72.8</td>
</tr>
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</table>

This high morbidity rate cannot be explained by greater accident incidence, the accident rate being 20 per cent, as compared with 10 per cent. as the average for all workers.
Diseases was 129 per 1,000 (average for the period 36-40 years may be regarded as critical periods for circulatory maladies. It is to be remarked that the diseases which provoke the greatest amount of incapacity do not come on suddenly, but develop in the course of several years, giving an appearance of being due to age (Anastasieff).

Lastly, varicose veins should receive mention. Some writers consider them to be most frequent amongst mechanics. In seeking a cause for this it is necessary to take into account the constitutional factor in the case and the same applies to haemorrhoids, which some writers hold to be more frequent among the train staff.

In the U.S.S.R., circulatory diseases would appear to be rare during the first year of work, but after that they are met with pretty frequently. After a duration of work of from one to five years more than a fifth of the subjects examined showed varicose veins; for later periods (five to twenty years) this symptom increases in frequency and severity and becomes the rule at the end of twenty-five years of employment (Anastasieff).

Blood. — Bobroff (1928) in the course of an enquiry covering over 260 engine-drivers and 187 firemen collected data enabling him to say that polycythemia is less marked amongst engine-drivers than amongst firemen, who show a higher incidence for leucocytosis. Among engine-drivers he also found slight pathological modifications of the red blood corpuscles, a tendency to leucopenia (leucocytosis among the firemen), a modification in the differential count (lymphocytosis, eosinophilia, monocytosis), and change of the neutrophiles to the right (to the left in firemen). The nature of this work, according to Bobroff, acts indirectly on the blood, causing alteration in the different organs, which in their turn, act on the constitution of the blood.

Diseases of the nervous system do not show special characteristics and it cannot be said that their number is considerable when it is remembered that under this head a number of widely varied diseases is included.

In Italy, a matter of fact, circulatory diseases show figures above the average (16 per 1,000) precisely in the classes showing also a low morbidity for rheumatoid complaints: station-masters, agents, etc., (22), clerical staff (21), while they predominate as a cause for retirement (general average 0.26) among workers on the permanent way (0.37), the train staff (0.33), and among the causes of death (general average 0.22), among the workshop hands (0.26) and station-masters, agents, etc. (0.34). Arteriosclerosis as a cause of retirement among the workers on the permanent way (0.88) and station employees (0.41) is very much higher than the average (0.34).

In Switzerland, the number of persons retiring on account of circulatory diseases is very high (almost double other causes) and higher still is the place those diseases occupy in mortality figures.

In the U.S.S.R., arteriosclerosis and dilatation of the right side of the heart were said to be very noticeable at the end of the year's work and were met with in 50 per cent of those examined at the end of sixteen to twenty years' service.

Duration of employment of eleven to fifteen years coupled with the age-period 36-40 years may be regarded...
(0.58), station employees (0.52) and those on the trains (0.45).

In Switzerland, the highest morbidity figures are those for the locomotive men (40 per 1,000), and workshop hands (37), the lowest being workers on the permanent way.

In the United States, in 1909, Edsall pointed to the frequency of right sciatica amongst locomotive men, due to the fact that they are in the habit of sitting on the edge of the bench, so much so that, in consequence of the constant vibration, the weight of the body rests mainly on the right thigh. A modification in the construction obliging the men to sit square immediately reduced the number of the cases.

A case of paralysis of the cervical plexus, manifested by double paresis of the pectoral, deltoid, coracobrachialis and biceps muscles on both sides with muscular atrophy, was reported by Curschmann (1927) in a workman employed in carrying rails on his shoulders.

Anastasieff, who has examined the statistics of various Russian sickness funds since 1925, as well as the medical examination files for locomotive men, considers that the most important pathological element arises from nervous diseases, the frequency of which increases with duration of employment.

As regards mental diseases, the average is exceeded in Italy by the clerical staff and train staff, the lowest being found amongst workers on the permanent way. The figures do not reveal the fact that nervous or mental diseases are particularly associated with any one branch of the railway service; their rarity indicates that any occupational pathogenetic element must be excluded, as, moreover, does their prevalence from the point of view of retirement among the clerical staff.

Nor is there evidence (at any rate for Italian railways) to prove that accidents or collisions result from a consequence of mental disease of the staff. An elementary measure of safety, however, must be frequent medical examination of the staff entrusted with the safety of trains (Filippini).

Diseases of the eyes have no particular feature because they are mainly the result of accidents (most often penetration by foreign bodies). It has been stated that locomotive men suffer from failing eyesight as a result of fatigue; but experience has shown that even after twelve hours' continuous work, at night and in tunnels, there is neither diminution nor failure of acuity of sight nor loss of colour sense.

Among persons employed on the American telegraph trains, McCord has reported cases of nystagmus.

Ear disorders are more frequent among locomotive men than amongst clerical workers, but they are still higher in the workshops where the risks involved are not similar. Generally the cases consist of chronic catarrhal otitis media, associated with stenosis of the Eustachian tube and naso-pharyngeal affections. The locomotive men also show a certain frequency of damage to the internal ear from vibration.

As for nutritional diseases it should be recalled that on certain American railways (Chicago North Western) a high proportion of excessively heavy persons has been observed — an observation not confirmed elsewhere. Recent examination of old employees, engine-drivers and guards has shown that 90 per cent. of the engine-drivers are too heavy and 60 per cent. weigh more than 100 kg. Almost all eat three times as much as they require (Dowdall).

Some writers (Navarre) have attributed the greater frequency of diabetes among the locomotive men to the action of train vibration. In Italy retirement for diabetes (57 cases between 1919 and 1928) was more numerous among the clerical staff (0.69 per 1,000) than among the locomotive men and train staff (0.64 and 0.61 respectively); it was least among the workers on the permanent way (0.09).

It is open to doubt whether Navarre's cases were not simple transitory glycosuria, which is not infrequently seen at a certain period of age, when the functions of the liver are no longer active. In addition to a high percentage of diabetes and hypertension among the engine-drivers on the Chicago North Western Railroad, Dowdall found 1.13 per cent. with glycosuria. As he fails to distinguish between the different categories of workers no conclusion can be drawn.

Cases of pulmonary tuberculosis in Italy oscillate between 2.5 and 3.3 per 1,000, with an average duration of 65-68 days per case. The cases represent only 2-3 per cent. of all maladies. Analysed as to the class of worker, tuberculosis affects especially the clerical staff (4.4 per 1,000), station employees (pointsmen, lampmen, etc.) (2.76) and station-masters, agents, etc. (2.52), workers on the permanent way (2.51), workers in the shops (2.09), train staff (1.91), and locomotive men (1.44).

The morbidity from tuberculosis is caused not only by variations in the
general morbidity from this disease, but also, among other causes, by the different criteria adopted in the selection of the staff (less rigorous examination during the war).

At any rate, the frequency of pulmonary tuberculosis among railwaymen can hardly be higher than that met with amongst the general population. As a matter of fact, the mortality was (1921-1928) 0.33 per 1,000, and, even presuming that the cases of retirement for this cause (0.58 per 1,000) ended fatally, which would be an exaggeration, there would be a mortality of 0.91 per 1,000 which is much below the 1.415 for the male Italian population from twenty to sixty years of age (1926).

The average of 0.91 is exceeded by train staffs (1.17), and station employees and clerical staff in stations (1.07). Show the figures 0.91, while lower figures are furnished by locomotive men (0.90), station-masters, agents, etc. (0.60) and workers on the permanent way (0.33).

In the United States in one section of a railway company the annual incidence of tuberculosis was 1 case in 800 employees (Philippi, 1929); in France (Paris-Lyons-Mediterranean Railway) the mortality from tuberculosis was 10.07 per 1,000, and in Switzerland the total retirement and mortality was 1.416 per 1,000.

Attempt has been made to explain the high percentage of cancer among railway workers by the fact that they come into contact with coal. But in Italy the morbidity from cancer (0.54 per 1,000 from 1914 to 1926) is noticeably higher amongst workshop staffs (0.65), train staffs (0.62), station-masters, agents, etc. (0.63), clerical staffs (0.62), and station employees (0.55), and is, on the contrary, lower among workers on the permanent way (0.53) and lowest of all amongst locomotive men (0.47), which comprises the workers most exposed to contact with coal.

According to English statistics, the section most affected is that of railway navvies or workers on the permanent way, and the most frequent situation is in the stomach. The least affected are locomotive men and cleaners, in whom the situation is predominantly gastro-intestinal.

In consequence of continual contact with the public and continual movement from place to place, railway servants are rather liable to contract infectious diseases.

In Australia these are by far the predominating maladies, especially if rheumatic affections and influenza are included, although these are generally considered apart. Typhus fever is found most frequently among train staffs (3.17 per 1,000 in Italy) subjected to frequent travel, though the latter are not subject to the same movement from place to place.

In malarial areas, this disease may represent an important cause of sickness for the railway staff. In Italy it represented, in 1889, 37 per cent. of all sicknesses, but now it has been reduced to 1.08.

Malaria is very severe among railwaymen in certain countries (Bulgaria, India). In India, recent study (1928) has been directed to determining precisely the measures to be taken against malaria when constructing railway lines.

Mention ought to be made also of diseases transmissible from animals to man which may be caught by railway employees who have to attend to trucks carrying animals or their products: cattle plague, anthrax, foot-and-mouth disease, etc.

Among the intoxications, the commonest is alcoholism, more frequent among station employees than among locomotive men or train staffs. It is also of common occurrence amongst workers on the permanent way. The frequency varies according to the countries: fairly low in Italy, where alcoholism figures at 0.16 retirements per 1,000 persons; cases of acute alcoholism which might entail destitution are exceptional. Alcoholism is fairly frequent among the railway staffs of central and northern Europe. In Switzerland, for example, since 1924, 1.76 retirements per 1,000 persons were due to this cause.

Excessive smoking is rare. This, it may be recalled, may cause transitory amblyopia.
Carbon monoxide is a real professional form of poisoning which may happen during passage through tunnels. In the past veritable catastrophes have happened through this cause, because the locomotive men and train staff became affected and the train was left to itself. This intoxication has, moreover, occasionally affected workers in the permanent way, especially those working in long tunnels. Among them effects of varying gravity have been reported from the lighter effects (headache, loss of consciousness) to a fatal issue. Allevi (1914) has reported cases of leucocytosis among the train staff after passage through a tunnel. This form of poisoning is said to have disappeared now by the introduction of better ventilation, and especially from the use of electric traction.

Medical literature contains also reference to a case of a fireman poisoned by sulphurous acid fumes liberated from patent fuel briquettes, which often contain sulphur.

Other occupational diseases may be observed among different classes of railway workers: dermatoses from impregnating and maintenance of the sleepers. Tar oil or creosote (in England, a case of skin cancer has also been reported) used for impregnation causes cutaneous lesions on the shoulder at the point where the sleepers are carried — skin of the collar bone and on the side of the back (Tichonmoff). The workers who lay them are exposed to the action of other deleterious products, which are given off when the doors of the impregnating chamber are opened: arseniugetted hydrogen gas and hydrochloric acid used to dissolve zinc, containing sometimes traces of arsenic. Skin eruptions have been reported among those loading pitch.

In France, Hudelet, Rabut, Cailliau and Mornet reported (1927) a case of melanodermy with, in six months, successive growths in the face upper limbs and abdomen, in a navvy working on the line, due possibly to the creosote in which the sleepers are steeped.

Lead poisoning among railway carriage painters in Italy has disappeared since the use of white lead was suppressed (1905) in that country.

Mention should finally be made of infection from acarasis, or grain disease, set up by Pediculodes verticorosus, of which cases have been observed among station employees and train staffs.

Van Themsche and Wautriche made a study of work in tending the furnaces in the engine cab. The work is hard, fatiguing and arduous, carried on in a hot and dry atmosphere. The principal danger present in this kind of work (operations of poking, levelling the crosspieces, the rivets of the seams, replacing the grills of the hearth, cleaning out the hearth, construction and repair of the vaults made of refractory bricks) arises from the excessive strain on the heart muscle as much as from remaining constantly in a hot and dry atmosphere. A second danger comes from the brusque change from an overheated atmosphere to a normal temperature. During the work, the worker is obliged to undergo an excessive thoraco-abdominal strain.

Accidents do not differ generally from those encountered in other engineering industries, except that they are in general more serious (Bogdan). They occur with varying frequency amongst the different classes of railway servants.

In Italy accidents represent one-fifth of the common maladies (106 to 250 per 1,000 insured persons) with a mortality rate of 0.35 to 0.62 per 100 accidents; in France (P.L.M. Railway) about one-tenth of the common maladies; in Switzerland in a proportion of 150 to 200 per 1,000.

These figures, as a whole, may not seem high in view of the industrial character of work on the railway, but it so happens that accidents constitute the most characteristic cause of illness among railwaymen.

Their frequency varies with the nature of the services, being highest in the shops, where accidents reach a proportion double that of the average.

In France (P.L.M. Railway) their maximum is highest for the locomotive staff and railway shop workers (the two departments being linked together) and lowest for the workers on the permanent way. The lesions for the most part are contusions and wounds; fractures and dislocations are rather rare. Oliver pointed out as early as 1902 that in Great Britain the three operations presenting special dangers were laying and repairing the permanent way, point work and shunting goods trains.

In Italy, permanent invalidity from accident, sufficient to lead to retirement of the victim, is found in almost equal proportions amongst locomotive men (0.90 per 1,000), workshop staff (0.88) and amongst station employees (0.84). Accidents causing mutilations are more frequent among snunters in stations and pointsmen, followed by brakesmen and workers on the permanent way. Mutilation of the lower...
limbs is much the most frequent. The death rate from accidents is highest among locomotive men, workers on the line and shunters in stations; it is lower for the men in the workshops.

In Switzerland mortality is greatest among the workers on the permanent way (0.9), after which come the station employees (0.7), then the locomotive men (0.7).

A type of characteristic accident is that due to crushing from the buffers during coupling of the carriages. According to an enquiry made by the International Labour Office, there were 2 killed and 50 injured per 1,000 persons employed as station staff each year.

In Italy, of 100 accidents due to imprudence or lack of attention to rules, those due to coupling number at least 5. The proportion then is not high; at any rate the obvious reasons for protecting the exposed person, as well as reasons of interest leading to the adoption of protective measures, are sufficient to prevent such accidents attaining high proportions.

The choice of coupling apparatus is not technically easy. Automatic coupling has been obligatory in the United States since 1893 (where, however, it does not ensure the automatic coupling of brakes and heating arrangements) and it has reduced accidents so caused by 83 per cent.

Japan is at the moment passing from one system to the other.

In 1930 a committee was formed by the International Labour Office to study this question.

Another type of accident which affects railwaymen to-day is that due to electricity. On Italian railways where traction is effected by steam, firemen whose shovels come into contact with the wire conducting the current are specially liable to such accidents. In Switzerland 27 deaths (either instantaneous or after some days) occurred between 1919 and 1926, and two cases of permanent incapacity.

When railway lines are under construction the sources of danger to navvies are accidents, malaria (in malarious districts), ankylostomiasis (tunnelling), and in tropical countries diverse maladies (dysentery, beri-beri) which affect imported rather than native labour. Generally speaking, it may be said that railwaymen have no specific diseases, not even when they are engaged on strictly railway work. Though certain diseases show a very high incidence, they do not exercise an injurious influence on the general health, and do not set up early invalidity or death.

As occupational diseases may be considered poisoning by carbon monoxide, kyphosis amongst coppersmiths and some other maladies to be found amongst certain categories and further, naturally, accidents.

**HYGIENE**

In view of the diverse character of the population concerned in railway work and their differing functions, necessity compels special hygienic measures for each group.
While general rules of hygiene (as regards cubic space, lighting, ventilation, washing accommodation, etc.) are of value for all railway staffs, they cannot for obvious reasons be applied in their entirety or even partially to such specialised classes of railway workers as locomotive men, train staff and station employees.

Night work, a rhythm of irregular work, exposure to weather changes, are unavoidable, and the hygienist can merely attenuate this state of things. As far as possible, hours of such length as will satisfy the industrial organisation and the just demands of hygiene should be advised. The chart on page 11 gives the hours for guards and stokers, the train staffs, for an Italian district, fixes 94 work days (585 hours 55 minutes on the trains, 126 hours 27 minutes of accessory work and 7 hours 47 minutes of journeys while not on duty; an average day of 7 hours 40 minutes, of which 6 hours 15 minutes is spent on the train), with 21 days' leave and 55 days in reserve (within call in case of necessity).

Analogous hour sheets have been laid down for the locomotive men. Sometimes, but rarely, when it is a question of long-distance trains, the train staff does 11 to 12 hours' work, followed by an adequate period of rest.

Sleeping accommodation should be provided for the workers obliged to sleep away from home. Modern types of installation have separate bedrooms, common-rooms, dining-rooms, baths, etc.

Efforts should be made to avoid, as far as possible, the necessity for the workers remaining in the brakesman's box on goods trains. The technical details for preventing exposure of the engine-drivers and stokers to draughts while watching the line should be studied and, for this purpose, lateral windows should be provided. Smirnov is of opinion that the hot air of the cabin should be removed by displacement (by opening the side windows) and that the incoming fresh air should be regulated by utilising the pressure of the outside air resulting from the speed of travelling, so that the layer of cold air forms a screen between the furnace and the working post. Automatic feeding of the hearths and the use of pulverised fuel should be encouraged.

Electric traction has many advantages: protection against inclement weather, suppression of draughts and variations in temperature. It obviates the radiant heat from the hearth, the laborious work of piling on the coal, the annoyance and danger from smoke. As a matter of fact, the Swiss statistics show a notable diminution in the morbidity figures of engine-staffs since the introduction of electric traction.

Analogous advantages have been obtained from the use of Diesel or electro-Diesel engines.

Waterproof clothing and shelters should be provided for those exposed to weather conditions, and hot drinks in cold weather, etc. Advantage would accrue if meals were provided for the staff on their journeys so as to compensate for the irregularity of their meals, and the food should be varied (Bogdan). In Germany the staff are provided with means for preparing and heating their food. Provision is likewise made for distribution of refreshments, coffee and non-alcoholic drinks. The buffet attendants are required to supply the railway staff with food and drink at a reasonable price.

Certain companies conduct an active propaganda for the limitation of alcohol. The Union of Railway Teetotalers, including all lines except those of Italy, Spain and Portugal, has not a large number of members, but the managements of the railways inflict heavy penalties on those guilty of alcoholic excess, and it is certainly a useful measure to prohibit, as some companies do (Bogdan), the sale of alcohol to railway servants during working hours.

Electric traction naturally does away with the risk of carbon monoxide poisoning in tunnels. With steam traction the tunnels must be well ventilated. In Italy the “Saccardo” apparatus has been used for a number of years and has given good results. When the danger of poisoning is great, suitable breathing apparatus should be provided.

As far as possible, mechanical means should take the place of hand labour: motor-driven trucks for the transport of luggage and goods, automatically discharging wagons (for coal and gravel), automatic methods of charging coal into the tenders and hearths of locomotives. Much of the work on the line can also be done by mechanical means.

It is superfluous to insist on the obvious necessity for prevention of accidents, seeing that they constitute the highest cause of morbidity among railwaymen. At the same time difficulties in regard to prophylaxis are greater for them than for the railway shopworkers, because in order to avert them appeal has to be made to individual attention. It is precisely for
this reason that selection of workers, especially on the basis of a psycho-
technical examination, might be pro-
ductive of favourable results.

An adequate organisation of first-aid equipment diminishes the consequences of accident: first-aid boxes at all the stations, permanent attendance of a trained nurse, permanent medical attendance at large stations. It would be useful also to have medical attendance on long-distance trains, and on electric trains mechanical means for effecting artificial respiration should be provided.

In railway construction, dwellings for the labourers should be built along the line, with requisite sanitary installations (washing accommodation, baths, shower baths, facilities for drying working clothes, etc.), means of medical-surgical treatment; and means for waging the campaign against malaria where this is required (see article "Malaria").

When making tunnels, abundant ventilation should be insisted on; attention should be bestowed on: the elimination of gases evolved in the course of blasting (many of the explosives used are very powerful), in the great tunnel through the Apennines, on the Bologna-Florence line, about 12,000 kg. of dynamite was used monthly and at the opening every month 2 million cub. metres of air were introduced, 450,000 of which was used for advancing, the prevention of ankylostomiasis (methodical examination of the stools of all the workers employed, movable latrines attached to the train carrying the workmen, etc.).

The welfare schemes, both hygienic and social, undertaken by the railway companies are numerous. For instance the sanitary service, the object of which is not only the discovery of illness, but also its cure. In Italy, this service, inaugurated in 1878, has organised health supervision of the personnel and has enlarged its scope further and further, limiting its health crusade to districts either malarious or difficult of access. This function has now been assumed by the National Association of Railway Servants, which also provides assistance to the families of its members. In Belgium, the medical services of the National Railway Society take on the functions of an insurance society (accidents to travellers, to persons injured not coming under Workmen’s Compensation Acts, accidents to persons not belonging to the service) or of an ordinary insurance office against accidents and diseases due to work; or of a large federation of mutual aid societies, or lastly as a service of industrial hygiene. In France the P.L.M. Railway possesses several medical centres with all the necessary means for diagnosis and treatment. The Paris-Orleans Railway has hospitals for dealing with social diseases (tuberculosis, syphilis, diseases of infants). The Midi Railway erected, in 1925, dispensaries at Bordeaux and Toulon for railwaymen and their families.

These services are situated naturally near the trunk railway lines in the different countries and they even have laboratories for research into questions bearing on the railways themselves (such as water, foods, etc.).

It suffices to mention also the accident, invalidity and old-age insurance schemes in force in many countries.

A very important initial step has been taken in the creation of housing facilities for railwaymen’s families, or for single men, which are let at moderate prices or sold on the instalment plan.

Lastly, besides the hospitals, sanatoria, dental clinics, etc., which certain railway companies (Japan, United States, etc.) have built exclusively for their employees, other companies have organised seaside or mountain homes for railwaymen’s children, or model villages for the railway staff, canteens for dispensing food of every kind at moderate prices, as well as institutes for recreation (conference halls, libraries, theatres, music, sports, etc.). (See also article “Social Welfare").

Tramways

The work of tramway driving entails remaining for long hours in an upright or rather hunched-up position, the legs spread apart on an oscillating floor, with ceaseless concentration of attention, executing all the time the same movements, and always holding the hands in the same position. In winter, too, it should be added, there is exposure to cold, aggravated by the necessity for maintaining an immobile position.

For the conductor a possible cause of risk comes from his continual contact with the public (from whom he may contract infection especially of the respiratory tract).

An enquiry in Russia in 1927 has shown that the work is constantly carried on under the influence of repeated shocks, which become more severe the worse the state of the vehicle. Another cause of fatigue is due to the fact that
the conductor must often descend to replace the trolley (Tatar).

For the road men (looking after the track), risk lies in exposure to the elements.

According to statistics published in Milan the morbidity rate for the tram- way staff per 100 workers was 81 to 100 for the office staff, 78 to 79 for the inspectors, 88 to 100 for the travelling personnel (drivers and conductors), 100 for the line-men, and 106 to 117 for the workmen.

The percentage of accidents was very high among the workmen (16-50), less high among the travelling personnel (9.5-13.3) and still lower among the men working on the line (8.4-8.8).

A statistical enquiry made in 1928 by the Moscow Government Social Insurance Committee dealt with the staff of the Moscow tramways, covering nearly 11,000 persons, of whom one-half were drivers and the other half conductors. The co-efficient of sickness (days of absence for incapacity per insured) increased from 14 in 1924 to 16 in 1925 and to 18 in 1926. During the same years, whilst the sickness percentage was 100 for the men, among the women the figures were 128, 150 and 137. A third of the sickness absence was caused by infectious diseases (influenza, phthisis), which totalled up to 25 per cent. more among the women than among the men; 17 per cent. of the general total was due to diseases of the digestive organs (mainly among the conductors); 8 to 10 to nervous diseases (mainly among the drivers).

According to English statistics of industrial mortality in the Registrar-General’s Report for 1921-1923, the comparative mortality figure for tramway drivers is similar to that of motor-drivers (875), but with a lower accident rate.

Tramway and omnibus drivers have a figure just below the average (990) and the principal causes of deaths are phthisis, cancer and appendicitis.

The incidence — very high according to some authorities — of varicose veins, hernia, flat feet, is said to be due to work in a standing position and is more marked among the conductors than the drivers. Filippini is of opinion that in the production of these lesions the constitutional element plays a role greater than the industrial, especially as one finds individuals with more than forty years’ service free from any symptoms.

Earlier observations made by Schwarze (1904-1906) reveal the relative frequency of hernia, which this writer explains by the bad attitude assumed by drivers in using the brakes, and among conductors by their habit of leaning backwards too much when replacing the trolley on the platform and the muscular effort entailed in getting off and on.

This author also reports an excessive frequency of conjunctivitis due to dust, draughts and eye strain.

Rather frequent also are said to be forms of a somewhat vague type of neurosis, with headache, vertigo, asthenopia, tremor, weakness of the legs, pains in the back, etc. The neurasthenia is of cerebral type with which are associated various troubles circulatory in origin (soft pulse, changes in blood pressure) and affecting the sexual organs.

Among the Berlin tramway drivers who continually strike a signalling bell, Schwarze has similarly reported neuritis of the right leg, as well as progressive atrophy of the shoulder and right arm muscles, of which the sole cause, in his opinion, is the continuous effort exercised for years in braking. Modern brakes acting by compressed air have however caused this form of injury to disappear.

Burns from the electric current (replacing burnt fuses, etc.) and shocks are rare (Schwarze).

Among women menstrual troubles and poverty of blood are frequent.

The observations of Raneletti and Fraschetti (1920) on women employed as drivers (49) or as conductors (304) show the injurious effect of this work on the female organism.

Measures of hygiene require first and foremost good construction of the vehicles and lines, so as to diminish shock and vibration, placing at the disposal of the driver a movable seat and one that can be lifted, which in some types of vehicle takes the form of a revolving armchair.

From a prophylactic point of view, trusses and elastic stockings are to be recommended for those predisposed to tissue weakness.

In order to avoid continual contact with the public, a kind of vehicle is being more extensively adopted in which the conductor is placed in a kind of niche and the public is obliged to pass before it to pay before leaving.

A French Bill (1930) requires the provision in public vehicles of seats for the employees.

Suitable hours of work should be made the object of further study and
likewise the provision of suitable seasonable clothing, provision of warm quarters, canteens (hot soups, tea, coffee). In certain towns in Switzerland (Geneva, for example) a tramcar which has been converted into a canteen runs along the line and stops at fixed places and hours at the disposal of the staff.

Underground Electric Trains

In many large cities electric railways have been organised, occupying a mid-way position between that of tramways and omnibuses and that of ordinary railway lines.

The conditions under which the drivers work are fairly similar to those of tramway drivers, except that, all the lines being free of all obstacles, attention is limited to observation of the signals.

The train staff assures the opening and shutting of the doors and the halts at stations. It is an operation demanding certain effort because it has to be done rapidly, but for some years now closure of the doors by hand has been replaced by automatic systems acting by electricity or compressed air.

These two classes, as likewise the station attendants, are subject to general conditions of life in artificial light, in a more or less confined atmosphere especially at the rush hours. As in the case of tram conductors, so here there enters a certain pathogenetic element in continuous contact with the public.

But the question that has pre-occupied hygienists most is that of the atmosphere of the tunnels and subways, although generally this has been considered mainly from the point of view of its content in bacteria.

A study (1920) of the Metropolitan Railway in London did not show, in the main, a greater richness in bacteria than that of the outside air (Graham Forbes).

According to Sutherland (quoted by Kober), the proportion of carbonic acid gas in the stations and carriages of the electric railways varied from 4 to 20 parts in volume when the air outside showed 2.8. A similar enquiry made relative to the air in the Metropolitan Railway in Paris (1928) covering chemical analysis, with inoculation of guinea-pigs in cages kept underground, did not reveal the air to have any injurious effect. On the other hand, examination of the staff did not show that those working underground presented any signs of tuberculosis.

Thus the enquiry was not pursued further.

Quite convincing is an old study made by Soper (1906-1907; quoted by Kober), giving the following results (per cent.) of analyses of air in the New York Metropolitan:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron in the form of very fine small particles</td>
<td>51.3</td>
</tr>
<tr>
<td>Organic matter, animal and vegetable</td>
<td>21.9</td>
</tr>
<tr>
<td>Mineral matter (mainly silica)</td>
<td>15.8</td>
</tr>
<tr>
<td>Oily matter</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>99.1</td>
</tr>
</tbody>
</table>

The average quantity of dust was 61.6 mg. and the maximum weight 20 mg. per 1,000 cub. metres of air. The excess of dust in comparison with the outside air was therefore 47 per cent. By suspending magnets in tunnels, Soper caught more particles of iron (from friction on the rails, slippers of the brakes, etc.) than he would have done in identical conditions in an iron foundry or in grinding and polishing shops.

Very few data can be found in medical literature relative to the pathology of the staff of underground railways.

Medical examination of the staff enabled Soper to report a very high incidence of dry pleurisy unattended by pain or physical discomfort (53 per cent. as against 14.5 among persons not working on underground railways), of congestion and inflammation of the upper respiratory tract which he attributed to draughty conditions and changes of temperature as well as to the nature of the dusts. But the reports are not of recent date. It is therefore highly desirable to have more numerous and precise data relative to the pathology of these workers.

Motorists and Chauffeurs

The principal factors causing harm to motorists are vibration, draughts, exhaust gases and prolonged nervous tension, not to mention the risk of accidents.

Available statistical data on morbidity among motor-drivers are recent, but are confined almost exclusively to bus-drivers. As regards mortality in England (1921) the Registrar-General gives a comparative mortality figure for motorists of 862—a lower figure than the average (1,000) for all occupied and retired males between twenty and seventy years of age.

As regards pathology many diverse symptoms may be shown, indicative of fatigue which may be due to very many causes—various noises in the car, lack of comfort, state of the road,
defective signal arrangements, dazzling sun, bright light signals, etc. In order of frequency the symptoms are frequent and un conquerable yawning, feeling of heaviness in the head, sleepiness even in holding the wheel, difficulty in falling asleep on going to bed, readiness to waken and nocturnal insomnia, anxiety and heart spasms, pathological absent-mindedness. These signs are aggravated in those who indulge in alcohol, even in moderate quantity. In a cold and humid atmosphere headache is said to be frequent and to cease generally soon after the subject finds himself in a warm place. Persons predisposed can protect themselves by adequate clothing and head gear (Boschi). English physicians have called attention to cases of fatigue from long motor-car journeys. On stepping out from his car the driver presents the spectacle of a symptomatic complex reminding one, at first sight, of an intoxicated person: tremor of the hands, difficulty in maintaining equilibrium, stiff movements, etc.

Petrazzani was the first (1907) to describe psychical troubles in a driver who had taken part in several races: mistiness before the eyes, confusion, inability to see the road properly, weakness of sight, nausea. The symptoms disappeared when a stop was called.

More recently (1926) G. Modena has again called attention to psychical troubles affecting drivers.

Cases of neuritis and perineuritis of the brachial plexus have been attributed to draughts striking the back and nape of the neck of the driver. A neuritis of the brachial plexus was described (1957) by H. S. Gaskell under the name of "motor arm" and was attributed also to the effect of a draught of cold air. In an open car the current of air strikes the wind-screen, rebounds in a semi-circle and strikes the back of the neck and back of the driver at the level of emergence of the 4th to 8th pair of cervical nerves. The trouble set up may take the form of pain and a "pins and needles" sensation in the brachial plexus and muscles of the forearm, or by pains localised in the splenius and trapezius muscles entailing rigidity and stiff neck. Many cases of typical radial neuritis have been reported in drivers of saloon cars where the drivers are in the habit of keeping the window on the windward side lowered. The pain in the arm is great, and the hand is sometimes doubled up. Pain increases on movement and with changes in the weather.

Motor-cyclists are less frequently affected (Gaskell) as they are generally better protected by their clothes; moreover the current of air catches them in front. A case of pain in the left leg was observed (resulting from the position of the leg) and also dragging of the right leg, which rubbed against the control levers; the compression on the peroneal muscle and the repetition of these little traumatisms induced trouble in the nerve and muscles.

Driver's talon douloureux (painful heel) may be seen after a drive necessitating frequent use of the pedals. The pain, which is said to appear generally on the following day, has its seat in the sole, especially at the points where the plantar fascia is attached, due to the facts that the heel rests merely its posterior surface on the ground and that it is in the position of dorso flexion of the foot to bring the pedals into action. These two factors, aided by the shaking, pull and strain the fascia. Serous bursae are also reported over the tendon Achilles (Bertwistle).

Calabrese (1934) has noted several cases of disease of the digestive system amongst motor-bus drivers and conductors.

Motoring exerts a pernicious influence on latent forms of cholecystitis, as well as on heart trouble and derangements of the appendix.

Persons with a vago-tonic tendency suffer from discomfort resembling seasickness when motoring.

In the case of slight lesions of the pelvic organs (appendages of the uterus, prostate, rectum), moderate and intermittent motor exercise may exert a favourable influence; in the case of advanced disease of this type, however, it is liable to aggravate the condition.

Motoring exercises a specially harmful action on gynaecological affections, and likewise on the health of women approaching the menopause.

As regards the urinaiy apparatus the automobile causes in particular a diminution in diuresis, which, in normal persons, is compensated for by polyuria after rest in a horizontal position. It occurs, on the other hand, more easily and is more obstinate in persons with slight renal insufficiency, but may have serious consequences for those in whom polyuria constitutes a compensatory mechanism.

Sometimes pain in the nape of the neck occurs with affection of the sight, brain fog, or general giddiness, which would point in a certain degree of renal insufficiency.

The strong air pressure on the eyeballs causes an infection of the con-
Transport Industry

Junctival vessels; a feeling of heaviness, running of the eyes, sometimes sufficiently abundant as to trouble vision; definite conjunctivitis with spasm and blinking of the pupils, and blepharitis.

The too rapid succession of luminous sensations suppresses or diminishes the retinal faculty of distinguishing properly the appearance of objects and fundamental colours; with this there may be dizziness.

Hearing also suffers. The drivers of large lorries are deafened by the continuous roar of their engines and their acuity of hearing is gradually diminished. It is for this reason that a periodic examination of these drivers has been suggested (Jacques).

Poisoning. — The exhaust gases always contain a certain quantity of carbon monoxide (1 litre of petrol equals about 530 litres), which increases if combustion is incomplete (when the motor is working badly or allowed to run free), in which case it may constitute 14 per cent. of the total exhaust gases. These also contain traces of methane, ethylene and acetylene hydrocarbons, as well as acrolein (in starting the engine).

The danger from carbon monoxide is especially marked in garages (see that article) and during the winter. The exhaust gases, further, may penetrate into closed cars (faulty floors) and thus cause poisoning.

In this respect systems of heating cars by apparatus through which the exhaust gases circulate are very dangerous.

Poisoning has been caused by petrol (washing the machine) and by benzol (mixed with petrol).

The troubles reported are various: headache, vomiting, loss of appetite, pallor, loss of mental control.

Mention should also be made of the risk of poisoning from the anti-knock substances added to the petrol and, in particular, lead tetra-ethyl (see that article) inside closed garages since the lead, which represents 64 per cent. of the weight and is found in the exhaust gases, may cause serious poisoning.

Petrol is now sometimes replaced by prop gas, obtained by the combustion of wood and charcoal which contains 25 to 27 per cent. carbon monoxide and 4-8 hydrogen. Heim, Agasse-Lafont and Feil have drawn attention to a new cause of industrial carbon monoxide poisoning which may happen when the gasogen is charged by the upper door, or when it is being cleaned from the lower opening, or when there are cracks and the gas escapes. Similarly, mention should be made of attempts to use compressed lighting gas as motive power.

The use of methyl alcohol as an anti-freezing mixture in the radiator would seem to represent a new danger for health. But an enquiry by the Bureau of Mines in the United States (1930) showed that there is no danger, that the data relative to poisoning by way of the skin are few and even these are not conclusive. All the same it is believed that continued exposure to high concentrations of the alcohol can set up severe troubles. The solutions of methyl alcohol used as an anti-freezing mixture should be coloured in order to avoid any accident.

Besides accidents due to collisions or overturning, the characteristic accident of motorists is fracture of the radius, described by Pouteau, Colle and Dupuytren, as a fracture "en dos de fourchette", caused by brisk return of the handle at the moment of starting. It is generally caused by marked extension of the hand along the forearm, but may also be due to tearing of pressure and flexion, as well as to any other mechanism. It is usually situated at the point at which the two upper thirds join the lower third. Research has been carried out in Germany more particularly with a view to discovering devices capable of preventing backfiring of the handle.

In Great Britain (1930) severe accidents have been reported on starting up. A youth, who for ten minutes had made vain efforts in turning the handle before making the engine start, complained the same evening of discomfort in his right leg, then loss of heat sensation and of pain radiating towards the thigh and right side of the abdominal wall as far as to 3 cm. above Poupart's ligament. Probably he had ruptured a small intramedullary blood vessel in the effort he had made. Another man, at the moment of starting, had the sensation of splitting pain and shock in the chest, followed by fainting. Here probably an aortic valve had been ruptured.

Alcoholism should also be borne in mind as a principal cause, especially at night, in numerous accidents. It is a nervous troubles, or simply fatigue after a long journey, may show a peculiar train of symptoms (stiffness, muscular slowness, staggering and motor inco-ordination), which may easily be mistaken for drunkenness. Nowadays methods allow of determining the amount of alcohol in the blood and urine in the living or in the organs in the dead body: methods of Nicloux,
Martini, Astruc and Radet, and Southgate.

Obviously, other habit drugs (cocaine, morphia, ether) detract from the skill of a good driver.

According to a study by Viteles and Gardner (1929), women taxi-drivers are more likely to have accidents than men, although it is not possible to say whether it is a question of relative inexperience or of a greater susceptibility to traffic accidents.

HYGIENE

Extremely long hours at the wheel should be avoided; the necessary measures should be adopted of avoiding causes of injury (discomfort from draughts, etc.; provision of closed cars and automatic starters; wearing of protective goggles and other means to prevent dazzle).

Care should be taken to see that the floor of the car is always in sound condition. (See article "Garages" for precautionary measures.)

The British Transport Bill (1930) proposes five and a half hours without a break on public transport services and heavy motor vehicles, with the object of preventing accidents from fatigue of overworked drivers. Exception is made in the case of fire and ambulance cars.

Medical examination should be made to eliminate persons with renal, liver and heart affections. Similarly there should be gynaecological examination of women seeking to take up public service, and work should not be permitted for them immediately after childbirth or miscarriage.

Carter and Coachmen

With the development of motor transport, horse transport tends to diminish more and more and to be of less importance. The data about the latter activity are, however, very scarce.

According to English statistics the comparative mortality figure for drivers of horse vehicles, principally employed in carrying merchandise, was 1,578, which is very high and well above the average for transport workers on the road. The principal causes in this excess mortality are cancer, respiratory diseases and accidents; but they are in large part to be more correctly attributed to social rather than occupational circumstances.

American statistics (1909), relating to 3,850 deaths, may be thus distributed in percentages: phthisis 25.9; pneumonia 12.5; bronchitis 1.5; other respiratory diseases 2.4; which would give a total of 42.4, although the percentage expected would be 26.5. Mortality from diseases of the heart and arteries was also in excess.

Hoffman considers that exposure to dust of roads and towns, inclemencies of weather, the arduous nature of the work, especially that of draymen and teamsters, are, in addition to alcohol, predisposing factors.

Maunlre reported (1930) Dupuytren's contraction among drivers, which he regards as an occupational malady.

Frequently in winter this class of worker suffers from frostbite of the hands and tips of the ear, and they are also exposed to certain infectious diseases (glanders, etc.) as well as to bites and kicks from horses, etc.

Kober suggests, among preventive measures, diminution in dust, to be obtained by proper road construction, and good methods of cleaning the streets in cities, etc.

Selection of Transport Workers

In the transport industry the selection of workers clearly corresponds with the collective safety of travellers and the public. For this reason probably railways were the first among the great industries to select the most suitable individuals for their own staff. Long ago a catastrophe at sea, due to inexact distinction of coloured lights, revealed the seriousness of this danger and the need was clear for having careful examination made as to colour blindness and acuity of vision.

Railways

Nowadays nearly all the large companies examine candidates prior to engagement on very much the same lines. The examination comprises the general state of health, but its strictness varies according to the countries and even according to the railway company in question.

With some the candidate has to answer a questionnaire dealing with illnesses and defects, and the medical examination includes examination of the urine, relation of height and weight according to the Quetelet table (France, P.L.M. Railway), etc. With others again, where no precise instructions deal with maladies and organic defects which might involve exclusion, a sound constitution, normal nervous system and physical and psychological aptitudes necessary for carrying out the special duties sought after, are insisted on (Italy: a height of at least
1.50 to 1.55 metres, according to the category, with a maximum of 1.70 metres for shunters and a minimum of 1.60 metres for brakesmen. In countries where the causes of exclusion are definitely stated (Austria, France, United States, Switzerland, etc.) rejection is made in the case of weak individuals, or those with heart disease, lung diseases, chronic intestinal disorders, kidney diseases, transmissible skin and genito-urinary diseases, advanced goitre, epilepsy, nervous diseases, bad skeletal deformities, changes in the blood vessels, etc. (Austria). For station and train work persons with chronic hoarseness and speech defects are rejected (Austria).

Too much attention cannot be bestowed on determining the existence of latent or recognised syphilis in the applicant because of the ocular and nervous complications which may develop.

Examination of the special senses (sight and hearing) is very important. The requirements as to sight vary a great deal: 6/6 or 5/5 for the locomotive staff (Austria); 14/10, without glasses, for both eyes, with at least 5/10 for one, for the categories of workers on whom the safety of the travelling public depends (France, P.L.M. Railway); 10/10 without glasses for each eye (France: State Railway); 0.7 at least for one eye and 0.5 for the other; use of glasses forbidden (France: Nord Railway); 12/10 for both eyes, with visual acuity of one eye not below normal (France: Paris-Orléans and Midi Railways). In Italy, acuity of vision for those concerned with safety must be 10/10 (optotypes of Monoyer) for each eye. For other categories, the requirements are less stringent and glasses are permitted. Correction by glasses is not essential for drivers, guards and workers on the permanent way. For others a maximum of 14/10 or 10/10, even after correction with glasses (respectively dioptries —4 or —5 or +5 or —10 is allowed). In Switzerland, visual acuity is measured by Snellen’s tables on a decimal system; A = 1.0 for every member of the locomotive and train staff is required.

In the United States, locomotive men, guards and pointsmen must have 20/20 for each eye without glasses; on subsequent re-examination 20/20 for one eye and 20/30 for the other, always without glasses; shunters, station employees and station-masters, etc., 20/20 for one eye and at least 20/40 for the other without glasses.

Ginestous considers that central visual acuity ought to be equal in each eye, examined separately, at 10/10 and that no optical correction should be accepted. In addition to the clinical determination and the central visual acuity, account should be taken of the quickness of vision (perception speed) and of the variations of acuity according to lighting changes, which bring out definitely the subject’s adaptive qualities to light.

The various companies require a normal field of vision.

The examination of the peripheral field in order to ascertain if the vision has preserved its normal extent in the peripheral field (investigation as to concentric narrowing, hemianopic scotoma), binocular vision (not often required), permit of verification of the soundness of the oculomotor apparatus.

All the companies require complete freedom from colour blindness both quantitative and qualitative. Only the methods of determining this differ (see the special publication of the I.L.O. 1 and report of Bourdier and Shaaff (1920)).

The Thirteenth International Congress of Ophthalmology (Amsterdam 1929), after having discussed the question of visual aptitude among aviators, motor-drivers, railwaymen and seamen, expressed the view that this question ought to be extended so as to include also the conditions of aptitude in respect of hearing and of the nervous system.

As regards hearing the whispered voice should be heard at 5 metres by each ear (Austria), or, for those on whom safety depends, at a distance of at least 1 metre (France: P.L.M. Railway), or for the same classes at 8 metres (Italy), at 6 metres on admission and at 8 metres on re-examination (speaking voice; United States, etc. For the other classes, generally 4 or 8 metres is required. In the case of noisy occupations (coppersmiths, iron beaters, etc.) perception of the spoken voice at 2 metres for each ear is enough.

Railway workers are subjected usually to periodic re-examination, the frequency of which varies according to class and according to age. These re-examinations relate to the general condition and special senses, having for their object the detection especially of signs suggesting alcoholism, syphilis, tuberculosis, epilepsy, diabetes, nervous disorders, kidney disease, derangement of sight, etc. For...

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the classes concerned with the public safety this re-examination is made every five years up to forty-five years of age, every three years from forty-five to sixty years, and every two years above that age (Austria). Persons showing haemeralopia are seen each year, and those showing signs of cataract every six months. Similar requirements are made in Germany. In France, revision by the P.L.M. Railway is carried out every seven years up to forty years of age and every five years above that age. The Midi Railway re-examines every five years up to forty years of age and every three years thereafter.

In Italy, re-examination is made of all railwaymen as soon as they reach forty-five years of age; in the United States every five years up to forty years and every two years afterwards. At this visit the blood pressure is measured; every person showing 150-200 mm. is placed under observation and those above 200 mm. are rejected.

The attention of engineers and heads of services should be drawn to the necessity for detecting signs of mental affections, such as change in character, intelligence, queer behaviour, which may be premonitory signs demanding an immediate examination.

Obligatory re-examinations are required also when change in the qualifications occurs (Austria, France, Italy, United States); when workers suffer from serious injuries or diseases of the head, eyes, ears, or when they become addicted to alcohol (Italy); after infectious, nervous or kidney diseases; after diabetes, excessive nicotine addiction, alcoholism (Austria); after accidents (Austria, France, United States); when there is doubt as to the physical or psychical state of the men (Italy, France, Midi Railway); when nervous manifestations occur or fears arise as to vision (France, Midi Railway), etc.

Certain railway companies also require psycho-technical examination (Germany, Belgium, Italy, Switzerland, Poland, U.S.S.R., etc.); these are made at special centres.

TRAMWAYS AND PUBLIC TRANSPORT SERVICES

For similar reasons most of the tramway and public transport services arrange for a medical and psycho-technical examination of applicants before engaging them. Generally speaking, these examinations cover the same ground as those for railwaymen: sound physical condition with intact functioning of the special senses, especially in the case of drivers and conductors. A central laboratory for the study of industrial diseases opened in Moscow in 1926 comprises the following sections; physiology, psychology, hygiene, anthropology, functional diagnosis, polyclinic, hospital treatment. The objects of this institute are: study of the physiological characteristics of the transport industry and its industrial risks, determination of the professional aptitude requisite for the different categories of workers; and utilisation of labour in accordance with individual aptitude.

Munsterberg, before the war, drew up a programme for psychotechnical selection, and, subsequently, Lahy (Paris), Stern (Hamburg), Tramm (Berlin), Houdmont (Brussels) and others at Rome, Milan, etc., have laid down methodical tests. Without desiring to enter into details in regard to the tests in use or proposed, the principal basis for the selection of drivers may be enumerated thus: study of the occupational reaction time; examination or chosen reactions; different reactions according to different forms of stimulation; measurement of the time taken to do certain things; control of precision with which those things are done.

Use is also made of classifying and consultant tests (Lahy). The former are so called because their standardisation is carried out with a precision sufficient for the values given to each subject to be compared with the results furnished by a large number of subjects, the occupational value of which is known. These tests are those of motor sensibility, of attention disturbed by visual and auditory stimuli combined, of the regularity of the reaction time, and its homogeneity.

The consultant tests do not present a sufficient standardisation, but the information they furnish can be utilised in the case where they show a clear inferiority among the subjects. They are tests for appreciating speed, rapidity of the reaction time, motor fatigue with measurement of the strength of tenacity, rapidity with which images are grasped, emotivity.

These tests are completed by tests carried out on the platform (tramway or motor-bus) when the occupational movements of the driver are studied whilst a film representing an everyday scene is unrolled before him, that is, the route along which the candidate will have to drive his vehicle.

Medical and psycho-technical examination is obligatory before admission. As in the case of railways, the
companies have also instituted periodic re-examination — compulsory, in certain cases, after accidents.

The practical value of the psychotechnical examination will be sufficiently illustrated on recalling that at Paris, during the first year of service, 100 drivers thus selected were involved or in accidents at a rate of 18.5 per cent. less than the number of non-selected drivers. At Barcelona 3 accidents to every 35 drivers who had not passed the tests occurred as against 1 to 45 drivers who had.

MOTORISTS AND CHAUFFEURS

The increase in motor transport and the impressive increase in the number of accidents requires that more and more attention be bestowed on the physical and psychical state of drivers. Many times medical examination has revealed defects of such a nature as to make it dangerous for themselves and others; defect in the special senses, loss of arm or leg, various organic diseases, psychopathies, etc. In a period of eighteen months Toulouse, Dupouy and Schiff (1925) examined 36 chauffeurs, of whom 24 were taxi-drivers, from the point of view of mental capacity, and found the following defects: psychasthenia, obsessions and impulses not amounting to insanity: 12; toxicomanias: 2; epilepsy: 2; chronic alcoholism: 5; alcoholsim with dementia syndrome: 2; various dementias: 3; general paralysis: 10. Analogous observations showing the existence among motorists of definite causes of incapacity to drive are numerous. In remarkably agreement among medical men has been arrived at as to certain physical and psychical aptitudes and inaptitudes. Heart diseases are a cause of rejection, especially when there are anginal attacks, myocarditis, lesions of the aorta or of the aortic valves; high blood pressure; diabetes (acidosis); certain nervous conditions (epileptiform seizures, psychical disturbances in arterio-sclerotic persons, giddiness, tremor, motor inco-ordination; Etienne 1929).

Rejection is called for also in the case of over-excitables, anxious persons suffering from phobias or obsessions who might be smitten with psychical inhibition under circumstances involving unexpected dangers; addicts of all kinds especially alcoholics (Aubry); persons with defective limbs (loss of arms or leg, more or less complete functional inability to use them, limitation of movements, paralyses).

Integrity of the special senses (sight and hearing) has similarly great importance. Good visual acuity (0.3 for the one eye and 0.05 for the other; 200 m. maximum sight over the road; Jeandelize). Rejection of the one-eyed (public transport) whom certain experts on the question of safety are inclined to admit. As a matter of fact, experience has shown that there are one-eyed persons who drive very well, just as there are good drivers suffering from the loss of an arm or leg. Persons with one eye are rejected in Germany for the occupation of drivers of public vehicles but they are allowed to act as private chauffeurs.

The visual field, ocular motility and sense of light should be normal. It would likewise be advisable to reject those suffering from homeralopia.

Diplopia, opacities in the centre of the cornea, detached retina; anything which retracts the field of vision should be regarded as a cause for rejection.

Acuity of hearing with both ears is necessary for the perception of noises and their localisation. Deafness in one ear is nearly as dangerous as deafness in both, because it hinders the determination of where the sound is coming from (Jeandelize). Candidates who suffer from buzzing in the ears, persistent noises (subjective abnormal noises or paracusis) should be rejected as this creates confusion with useful noises. Persons should also be rejected who suffer from failure to maintain equilibrium, vertigo. Motor-car driving is never advisable during attacks of rhyno-pharyngitis with intermittent deafness.

So far as aptitudes of a psychical nature are concerned, the general mental state should be sound and, everyone suffering from mental affections characterised by hallucinations, mania, impulsiveness, obsession, paranoia, or general paralysis should be rejected. Qualities, such as power of attention, sensorial perception, motor reactions, exact appreciation of speed, of distance and of time, should be quite sound.

Among the studies on psychometric and autographic examination of motorists, those of Patrizi and his pupils are very important.

LEGISLATION

Several countries require medical examination before applicants are given driving licences. According to an enquiry conducted by the International Professional Association of Medical Men in 1928; in this examination is compulsory in Austria, Bulgaria, Danzig, Denmark, Estonia, Finland, Germany, Hungary, Italy, Latvia,
Luxemburg, Norway, Netherlands, Poland, Spain, Sweden and Yugoslavia. In France, Great Britain and in certain cantons of Switzerland it is only obligatory for drivers of public vehicles.

In Belgium the regulations specify that the drivers must possess the physical qualities required, and the Belgian Academy of Medicine has laid down the tests with which drivers of public vehicles should comply.

It is not possible to enter into the details of the different regulations in force. Some countries apply these in general terms (Danzig, Estonia, France, Hungary, Latvia, the Netherlands, Yugoslavia), while others define them more precisely and even specify the causes of rejection. These relate to the general state of health (Austria, Denmark, Estonia, Norway; or special senses (sight): Austria, Bulgaria, Denmark, Estonia, Germany, Italy, Luxemburg, Norway, Sweden (hearing); Bulgaria, Denmark, Estonia, Germany, Italy, Luxemburg, Norway, Sweden for which minimum have been fixed, as in the case of railway employees.

The requirements as to sight and hearing are less severe for drivers of private than for public vehicles (Germany, Italy, for example). The medical certificate may last for all time, or must be renewed every three years (Poland), every five years (Denmark, Finland, Latvia), every five years for sight (Norway), when an accident happens (Latvia), when temporary withdrawal of the licence is made.

Compensation for occupational diseases is only granted under Russian law, which awards compensation for Dupuytren's contraction among mechanics.

Certain countries, however, or certain State railways (Italy, for example) award compensation for certain specified diseases (chronic poisoning from toxic gases; chronic respiratory diseases from inhalation of irritant gases or dusts; deafness due to noise; chronic recurring dermatitis; eczema from exotic woods and among workers occupied in impregnating sleepers; retinal atrophies — death; workers engaged for ex-due to prolonged action of corrosive substances; retinal asthenopia and other ocular lesions among soldiers, casters and electricians; mobigraphia, industrial cramp, Dupuytren's contraction, caisson disease) occurring among railwaymen and workmen employed in railway workshops. The organisation of health work as it exists in connection with the railways in most countries renders impossible comparison with similar organisation as adopted in industry.

BIBLIOGRAPHY

The bibliography on this subject being very wide, the reader is referred to the quarterly publication of the International Labour Office: Bibliography of Industrial Hygiene.

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(k) Porters and Workers Engaged in All Forms of Transport and Propulsion other than Mechanical

French: Transport par l'homme : portage.
German: Träger.
Italian: Lavoratori addetti ai trasporti.
Spanish: Portadores.

GENERAL

This section deals with employment in which transport is an end in itself, and workers devote all their energy to that particular activity, substituting their muscular strength for that of animals or inanimate motors, even for considerable distances.

Among these workers there are some who do porters' work all their lives; others who are employed temporarily or only on certain occasions, e.g. young boys who commence work as carriers of various things for some years before being accepted as apprentices, or skilled workers who may be compelled to act as porters during periods of unemployment, or to work in making roads or fortifications, or in improving rural districts. The number of these workers is still considerable; but it varies greatly according to the country, and sometimes according to districts. The absence or impassableness of roads, a scarcity of animals or of vehicles, and of adequate equipment for them, a superabundance of manual labour, ignorance or incapacity for following other trades — all these factors affect the development of transport by man. In some regions these conditions are in-keeping with a low standard of civilisation, which may approach that of slavery.

In former ages the number of men employed as porters was much greater than at present Herodotus, for example, records that the building of the great pyramid of Cheops lasted thirty years and necessitated the employment of 370,000 slaves, half of whom died at the work, although they were changed every three months. Even to-day, in the interior of Africa, natives have to undertake forced labour which, for the most part, consists in carrying on the back, and has caused a cruel decimation of the population of certain districts (Goudal).

The question of forced labour, which was discussed at the International Labour Conference of 1929, is thus identified very largely with the question of transport.

A particular aspect of the risks for transport workers (see article "Dock Labourers") is also the question of
accidents among labourers employed in loading and unloading ships.

In many parts of Asia, and even on the coast, carrying chairs are used, not only in the towns, but also for quite long journeys. In other countries, such as China and Tonkin, there are still in public use in towns rickshaws drawn by men, an occupation which is fatiguing, dangerous and disagreeable; it is not only a source of injury to health, but is an offence against the dignity of man.

Whilst it is to be deplored that the number of human beasts of burden ( caballus) as Plautus, quoted by Ramazzini, calls them, is still considerable, it must be realised that in civilised countries, wherever there is economic progress, there are still, and there will always be, many conditions which demand human labour for such transport work as loading and unloading animals or vehicles, putting goods or furniture into warehouses or dwellings, the harvesting of food crops, laying out certain kinds of ground, building work on mountains and handling small ships; here human labour alone is able to adapt itself to the most varied conditions of weather and situation better than animals or mechanical means can do. But the diffusion and perfection of modern mechanical devices will tend to make man’s share in such toil increasingly rare.

Methods of transport by human labour are dependent on the direction through which the goods have to be moved, whether it be horizontal, vertical or oblique, on their shape, size, weight, their degree of cohesion, their resistance and hardness; also on the nature of the journey, whether by land or water, which in the former case will present varied resistances according to the state of the surface and according to the incline, and in the latter according to the presence of more or less strong currents. These methods of transport are also considerably affected by the help furnished by certain tools and appliances, such as levers, capstans, windlasses, pulleys and small trucks, as well as by local custom, or by some necessity for fitting in with special conditions. As regards this point, it is interesting to consider the various methods used, among different peoples, by mothers for carrying their children: — on the arms drawn up towards the chest in Europe, on the hip in Annam; or seated on the muscles of the buttock among Hottentots; or suspended on the back by means of a large band or a small bag, the ends of which cross in front of the chest, in China and Japan.

Every change in the position of the load, in the manner of fixing it and carrying it, exercises a different effect on the body and modifies perceptibly the conditions of the physiopathological problem.

The method of transport engaged in by man can be reduced to the three following types: (a) carrying the load on the person; (b) drawing or pushing the load; (c) raising or lowering the load.

These three methods can be subdivided into numerous other secondary methods.

Carrying on the Person

(1) The load may be placed on the top of the head (sinciput), with or without help from the arms; this method is chiefly used for carrying stones, bundles of wood, or receptacles containing water or provisions.

(2) The load may be placed on the upper part of the back or on the neck with or without help from the arms, as when carrying very large or very heavy objects, and with a band which encircles the forehead, especially on long journeys.

(3) The load may be placed on a shoulder, with or without the support from the arms, as when carrying kegs, sacks or planks, or on the two shoulders, as for wooden ladders, stretchers or carrying-chairs. A variation in the last method consists in hanging the objects to the two ends of a stout stick held horizontally on a shoulder, as when carrying with a yoke, or with a balancing pole, or on the two ends of a strap.

(4) The load may be placed on the shoulders with bands or straps, hanging from the trunk, either in front, like a French postman’s box, or the boxes of itinerant vendors, or on the side, like a scholar’s satchel or the soldier’s haversack, or at the back, like the pack of the soldier, the rucksack of the Alpine climber, or the basket of the mountaineer. The basket is often furnished with a frontal band, in addition to straps supported by a shoulder girdle, and rests on the lumbar region of the back.

(5) The load may be placed on the two forearms, or on one, with or without the aid of the hands. The principal varieties of this method of carry-
may be supported on the abdomen, as when carrying bundles, faggots, or parcels held under the arm. iliac crest, as when carrying bundles, firewood, bricks or trays; arms folded in a lateral curve to the trunk, with or without support from the hands on the back, i.e., with the arms extended or folded, but held at the side of the body, as for sacks, small trucks, or boxes; or with the arms extended or folded, but held at the side of the body, as for stones, kegs and heavy or bulky parcels; or on the coils, as for sacks and furniture, or persons sitting astride.

Loads Drawn or Pushed

On land the loads may be pushed with the arms extended in front, as for casks, small trucks, or boxes; or with the arms extended or folded, but held at the side of the body, as when moving various wheel vehicles furnished with shafts; or drawn or hauled by holding the shafts or ropes with both hands, or attaching ropes to the body in different ways; or using vehicles moved by the feet, such as peda l-bicycles or tricycles.

On water the unloading of boats, the pulling of fishing boats ashore or the nets to land in line fishing, presents operations similar to drawing and pulling on land, and the body takes up the usual positions.

During the act of rowing, the position of the body varies according to whether the act is effected by indirect impulsion, or from the bow of the boat, with one or two oars, in a sitting or standing position, with a fixed or sliding seat. A particular kind of rowing is used by the Venetian gondoliers, who stand on the poop and use a single oar.

When it is a case of pushing boats and rafts along on shallow rivers or lagoons, the boatman plants the lower end of the oar obliquely on the bottom of the lagoon, holds the other in the external subclavicular hollow; and then, using all his weight, pushes the boat backwards with his feet.

Raising or Lowering of Loads

The raising and lowering of loads includes hand transport from a lower level to a higher, or vice versa; it comprises loading and unloading loads, on the man's own person or on another person, on an animal or on a vehicle; the lifting of materials for building walls, or the stacking of goods. The positions of the body vary according to the weight of the load; the height and position of the levels from which a load is lifted and to which it is moved; and the vertical or oblique traction of a load by means either of a free cord or one passed over a pulley or a windlass.

The classification of the methods of transport just described is simply schematic, for these methods depend on individual habits, local customs, and special circumstances of the work. It may even be stated that for the same work the variations are more numerous than the movements and the attitudes adopted. Yet a precise analysis will disclose numerous analogies, not only between the different methods of carrying, but also between these and other muscular work which has not transport as its object.

It is, therefore, advisable to analyse the various kinds of transport and to take into account the attitudes of the body in all their phases, if the object is to make a conscientious physiological study. Attention will here be confined to illustrating the principal methods already classified, since the facts which concern them are easily applicable to methods which are derived from them or are similar.

Physiology

The problem for the physiologist consists in calculating the necessary effort — the energy-cost of the work — and in studying methods of participation by the different parts of the locomotor system and the internal organs.

For calculating the effort, it is necessary to consider both the exertion required to maintain the equilibrium of the body, i.e., static work, and also that necessary for moving the loads, i.e., dynamic or effective work.

Effort of Equilibrium

This effort is very pronounced in all methods of carrying of loads on the back. On the other hand, it is almost nil when drawing or pushing loads, or when lifting or lowering with machinery, because then the body finds a fixed point in the resistance of the load.

The amount of the effort depends partly on the weight of the load, but chiefly, on the method of carrying it. Even when no load is carried, a man in the upright position cannot preserve the equilibrium of the body and
avoid oscillations without carrying out static effort, due to muscular contractions with their consequences of bad circulation and fatigue, which is greater than the dynamic effort of slow walking. This latter requires in a man weighing 67 kg. 2,377 calories a day, or nearly 253 calories, or 12 per cent. more than those used up by a man in absolute repose (Zuntz). The upright position, at ease, on the contrary, requires 2,441 calories, or 15 per cent. more; and the rigid position or position of attention of the soldier, 2,548, or 20 per cent. more (Katzenstein). The centre of gravity of the human body when upright is at 57/100ths of its height above the ground, a point which lies between the promontory of the sacrum (Weber) and the upper border of the third sacral vertebra (Braune and Fischer). In the symmetrical vertical position, heels together, known as the "position at ease" of Braune and Fischer, not only is the effort less, but the equilibrium is yet more stable than in the rigid upright position, because in the first position the line of gravity passes 4 cm. in front of the line which unites the centres of the femoral heads, and touches the ground almost at the centre of the base of support of the body, that is to say, almost at equal distance from the two lines which unite respectively the heels and the toes, whilst in the second position the line approaches nearer the heels. The separation of the feet, one from the other, improves equilibrium, in consequence of the enlargement of the base of support. But, for a man standing still, the most comfortable and economical position is the lateralised position, resting on one hip, that is to say, resting on one leg whilst the other is ready to correct any small oscillations of the former.

Locomotion continually causes displacement of the centre of gravity as well as the base of support. Yet the energy-cost of maintaining equilibrium is less than that required to maintain the body still in the upright position, and this is so particularly in walking with short and slow steps. The same advantage is found in walking when a weight is carried which necessitates inclining the body forward. Ramazini has observed that a load is carried more easily on the shoulder with the body bent: "that is why porters and those who are carrying loads lean forward and push out the middle part of their body behind, so that the centre of gravity is found in the axis of their direction."

In order to estimate the effort of equilibrium, and also to take into account other factors, it is necessary to remember the following general law: "For equal loads, the muscular effort is greater in proportion to the degree to which the point of support for this effort is eccentric."

1. Carrying loads on the top of the head should theoretically be the best, for the axis of gravity of the load coincides with that of the body. However, it is often neither the most convenient, nor the most economic for heavy weights, because the load is badly supported by the cranial vault and the centre of gravity is raised, but particularly because all the muscles of the neck and part of those of the trunk are strongly contracted, while the arms have to be raised very high to support the load. This method is fairly efficient in the case of light loads, carried for a short time. Women, however, almost always prefer it as being more aesthetic than the others. As a matter of fact, when walking, the forced immobility of the head, neck and upper part of the trunk is compensated by an undulatory movement of the hips which is not ungraceful.

2. Carrying on the area which includes the upper part of the neck, the nape and shoulders is more comfortable and more economical, especially in the case of a heavy or bulky load. The area on which the load is placed is a large, firm surface, made up by flat bones, strong masses of muscle and pads of fat; so it is well adapted for carrying heavy bodies. This method has the advantage of lowering the centre of gravity, and of distributing the load better on the powerful dorso-lumbar muscles, the resistance of which is greater than that of the muscles of the neck. Further, when the raised arms are used to keep the load in position, less effort is required than that necessary for keeping the load on the head. Finally, if the arms are curved, with the hands resting on the flanks, the deltoid area contributes to enlarge the surface of the shoulders, so that the work of the dorsal and lumbar muscles is lightened. However, the axis of gravity in this method of transport on the shoulders can hardly ever coincide with that of the body. But the displacement and the consequent effort to maintain equilibrium remains quite slight if the load is distributed equally around the axis of gravity, transversely on the two shoulders, or in the sagittal direction,
with part before and part behind, or obliquely.

According to Speck, the consumption of energy for transporting a load of 25 kg., placed symmetrically with the line of gravity, is not markedly different from that required to keep the body upright at ease. On the contrary, the same weight, carried on a single shoulder requires a consumption of energy of 7 to 30 calories per kilogram per minute greater than the consumption required by ordinary walking. For the most economic transport possible of a load, it is necessary, according to Bedale and Vernon, that the human body should be displaced as little as possible from the vertical position, while the load should be equally distributed around the line of gravity of the body.

An example of transport of baggage in wallets is a double sack such as friars and peasants carry on the neck; or again two buckets may be fixed at the ends of a pole kept in equilibrium on the shoulder in the sagittal, transverse or oblique direction; and two valises joined together by a leathern strap imitating the valises, and two valises joined together by a strap or a band, is frequently used when the weight is not excessive or partially free, in the end it is more fatiguing (than carrying on the shoulder by holding them on the back, or when it has to be carried a long time.

A method which consists in carrying the load hanging against the trunk, either in front or at the side, but attached to the shoulders by a strap or a hand, is frequently used when the weight is not excessive or when it has to be carried a long time.

A method which consists in supporting the loads on the pelvic girdle, and has been proposed for soldiers because it has the advantage of decidedly lowering the centre of gravity, of having a rigid base on the iliac bones and of not straining the muscles or articular ligaments, on the other hand renders the movements of the legs and arms more difficult and leads to loss of the advantages accruing from diminution of the oscillations from the line of gravity on the march, and from cessation of the efforts of the trunk muscles. It is only an auxiliary means for lessening the weight on the shoulders and on the back, and is especially suited for carrying articles which are not bulky, such as cartridges.

(4) At least as fatiguing as the preceding is carrying on the forearms, that is to say, between the trunk and the curved arms, with the exception that in this last case there is the pos-
sibility of resting the load on the iliac crest. The effort is still greater when the arms must be stretched in front and the load is supported not on the forearms, but on the hands, as waiters do when carrying plates.

(5) Carrying by hand with the arms hanging the length of the flanks, or slightly bent, requires a consumption of energy of 30 calories per kg. per minute higher than is necessary for carrying on the shoulders a load arranged symmetrically to the line of gravity (Speck). Miss Bedale has also found this method less economic than carrying with the yoke.

The beneficial result of the considerable lowering of the centre of gravity of the body is annulled, for, whilst walking, the body oscillates continually from one side to the other. The load then interferes with the movements of the leg and compels the carrier to make a supplementary effort to replace the body at each step in the line of gravity and to hold the arms out away from the body. If the load is held by only one arm, the effort of equilibrium is the maximum of that required by all the other methods of transport; it compels the porter to hold the opposite arm raised horizontally to make a counterweight.

The carrying of articles with the arms hanging down is, for short distances, the method of transport which is preferable to all others, because it is more dignified than carrying on the shoulders, and affords the convenience of enabling the carrier to put the load down and take it up easily.

The carrying of loads held by the hands, but resting on the abdomen, does not call for an effort of equilibrium greater in general than that necessitated by carrying on the shoulders, and affords the convenience of enabling the carrier to put the load down and take it up easily.

(6) The lifting or lowering of a load by the arms without the use of such appliances as pulleys or windlasses is an operation which must be done in several phases in order to be able to calculate the effort of equilibrium.

In the case of heavy objects, a man instinctively tries to hold them as much as possible resting against the body, to take them and put them between the separated legs, in order not to displace too much the line of gravity of the body. On the other hand, the maximum effort is required for lifting with legs and arms rigid.

(7) The effort of equilibrium necessary to lift a weight by means of pulleys and windlasses is nil, if the man pulls on the cord of the pulley or on the crank of the windlass in a vertical direction; it increases when the direction is oblique, and is still more when the direction is horizontal. But practically speaking it is almost nil in every case. As a matter of fact, a man deliberately opposes his weight to the weight of the load in order to save the effort of pulling.

The practical problem of determining the effort of equilibrium in the work of drawing or pushing, whether applied on land or water, presents itself in an almost identical manner. In all work of this kind, the static effort is mixed up with the dynamic effort, so that it is almost impossible to separate them, because a man never holds his body in a vertical position, but inclines it more or less voluntarily, using his weight, when that is possible, to overcome the resistance of the load.

The Effort of Carrying

The expenditure of energy, i.e. dynamic work, in carrying loads naturally depends on a number of variable factors, of which the chief is examined below.

Investigations into the effect of weight and speed on the expenditure of calories in walking with a load have given most contradictory results. According to the experiments of Zuntz and Schumberg, a man of 70 kg. doing 75 metres to the minute (or 4.5 km. per hour) on a level road expends:

<table>
<thead>
<tr>
<th>Calories per minute</th>
<th>Calories per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without load</td>
<td>3.0</td>
</tr>
<tr>
<td>With a load of 22 kg.</td>
<td>3.9</td>
</tr>
<tr>
<td>... 28 kg.</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Whilst walking up a gentle slope of 1 in 10:

<table>
<thead>
<tr>
<th>Calories per minute</th>
<th>Calories per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without load</td>
<td>6.90</td>
</tr>
<tr>
<td>With a load of 22 kg.</td>
<td>7.8</td>
</tr>
<tr>
<td>... 28 kg.</td>
<td>8.1</td>
</tr>
</tbody>
</table>

Amar, by observations on natives of North Africa, carrying 40 to 60 kg. at a maximum speed of 4-5 km. per hour during a daily march of about eight and a half hours, found the average expenditure excessively low, namely 0.311 call. per metre-kilogram. As regards speed, the same authority gives the following figures: speed: 80, 120, 180 metres per minute; expenditure of energy: kilogrammetres: 0.088, 0.119, 0.176 per metre-kilogram.
Kaploun found the following expenditure of energy per 100 kilogrammetres in two women carrying loads:

<table>
<thead>
<tr>
<th>Calories per 100 kilogrammetres</th>
<th>Woman</th>
<th>Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>With a load of 30 kg.</td>
<td>31.4</td>
<td>36.8</td>
</tr>
<tr>
<td>40 kg.</td>
<td>38.8</td>
<td>38.8</td>
</tr>
<tr>
<td>50 kg.</td>
<td>30.0</td>
<td>33.4</td>
</tr>
<tr>
<td>60 kg.</td>
<td>40.2</td>
<td>45.8</td>
</tr>
<tr>
<td>70 kg.</td>
<td>44.5</td>
<td>47.4</td>
</tr>
</tbody>
</table>

Some interesting investigations on the most economic method for carrying by man, that is, on the method which will give the maximum weight which can be carried without ill-effect to the body during a day's work, as well as the relative duration of periods of walking with the load and returning unloaded, i.e. of rest, have been made by Kolmer and Brezina in the case of a man of 70 kg. who carried varying loads of 11, 21, 33, 43 and 53 kg. on a track of about 155 metres at a speed of between 3 and 6.6 km. per hour. The smallest expenditure of calories per metre-kilogram was obtained: in walking without a load at an hourly speed of 4,200 metres (0.508 calories); with a weight of 11 kg. and an hourly speed of 4,200 metres (0.554 calories); with a weight of 21 kg. and a speed of 4,200 metres (0.454 calories); with a weight of 33 kg. and an hourly speed of 4,800 metres (0.523 calories); with a weight of 43 kg. and a speed of 4,800 metres (0.600 calories).

With 53 kg. it was necessary to reduce the hourly speed to 3,000 metres in order to have an expenditure of calories below 0.60 per metre-kilogram (the actual expenditure is 0.547 calories).

The best return was obtained when the load was 21 kg. and the hourly speed 4,300 metres. On the other hand, Kaploun found a sharp rise in the consumption of oxygen and in the expenditure of energy (calories) when a weight of 60 kg. was substituted for a weight of 50 kg.

The results would show that increasing the load always has an anti-economic effect, and the consumption of energy increases more rapidly with an increase in the load than in the speed.

Increase of speed can be especially useful in the case of short distances, and, indeed, porters are often seen to quicken their pace when they carry heavy loads. But for long distances and above a certain hourly pace (about 4,500 to 4,800 metres) speed increases in a very pronounced way the energy-cost of work, especially if the load is heavy. A man of 71 kg. carrying a load of 60 kg. was able to cover in a day 22,311 km. at an hourly speed of 4,824 m. But, on the other hand, he could not do more than 12,140 km. (or a little more than half), if the hourly speed was increased to 5,400 metres, or scarcely 576 metres more (Amar).

If, then, the most economic speed per hour is considered to be 4,200 to 4,500 metres the optimum weight should be 21-22 kg. This work becomes less economic as one gets further away from this weight. The observations of Zuntz and Schumberg on a soldier of 70 kg. carrying a load of 52 kg. and doing a daily march of five hours confirm this conclusion. In reality the soldier effected in two hours an expenditure of 4,312 calories, that is to say, much more than the 3,561 calories expended, according to Rubner, by a man doing moderately fatiguing work. By observation on officer cadets of the Frederick-William Institute, these same authorities found, when the loading weight reached nearly half the weight of the body (31 kg.), in spite of improved conditions of marching and of the temperature of the air, that serious physiological disorders were observed.

Further, with a load of 31 kg. young men under observation could not be successfully trained. On the other hand, the signs mentioned above did not appear or disappeared rapidly when the load in use was reduced to 22 kg.; hence, with this load, the young men could always be trained. Only a few cases were able to become inured to a minimum weight of 27 kg. It can then be said, speaking generally, that the normal effort of a man who covers 22 to 25 km. a day at an hourly speed of 4,200 to 4,500 metres is that which consists in carrying about a third of the weight of his own body, i.e. from 20 to 25 kg.

Cailhcart, Bedale and Overton have also confirmed that the limit of load for a woman should not exceed 35 per cent. of the weight of the body. This is also the result of numerous investigations on bodily resistance not only in the case of soldiers, but also on mules and horses which become rapidly fatigued when they carry a load of greater weight than a third of their own weight.

Patrizi, having observed that a load of 22 kg. carried by a man in the upright and right position has on a dusty road caused after some minutes, marked reactions in the cardiac and respiratory apparatus, drew attention to the fact that the weight to be carried should undergo a 'decided diminution.
as compared with the averages accepted by tradition and propounded up to the present time by empirical observation. And he adds: "To recommend that a load of almost 25 kg. can be doubled, or even increased to 60-65 kg. (that is to say, to approach the average weight of the human body, which is the equivalent of compelling an individual to keep mounting a staircase the whole of the working day, even with long pauses), is to display that physiological ignorance so much to be deplored among well-known industrial organisers of labour."

Apart from weight and speed, the greatest practical importance must be given to the length of the period for which the load is borne, and to that of intermediate pauses or times of returning unloaded. Taylor found that whereas loaders of pig iron were able to carry at each journey 41 kg. to a distance of 11 metres on ground partly level and partly slightly inclined (the ascent to 60 cm.), they were scarcely able to do it during 43/100 of the working day of ten hours, and that the 57/100 were occupied in returning unloaded. When an attempt was made to increase the carrying time to 58/100 of the working day, or scarcely 15 per cent. more, it was necessary to reduce the journey half or to 2 kg.

In the experiments of Amar already mentioned, on cases who were quite accustomed to walking with loads, the results indicated, which the author has defined as a "maximum maximum" of the development of energy, could not be obtained except by giving 2 to 5 minutes' rest per kilometre, or one or two minutes every 600 metres.

The inclination of the ground to be traversed is a very important and variable factor. According to Zuntz the expenditure of energy per unit of work is 68 calories per kilometre for a distance of 6 km. with 25 kg. load; 49 calories per 100 metres for a distance of 300 metres on an incline; 58 calories for 100 metres on a steep path with a gradient of 53-68 per cent.; 89 calories per kilometre for an ascent of 3 km. on an inclined path.

If the expenditure per kilogrammetre (horizontal, walking on the level) be considered as equal to 0.51 calories, the expenditure for mounting a staircase can be calculated at almost 8 calories, or sixteen times more (Amar). Coulomb has estimated eighteen times greater, and Haughton twenty times; but the proportion which seems to be the most accurate is that of sixteen times. As regards walking, on an inclined surface, the expenditure is about 7.40 calories per kilogrammetre when the gradient is 0.08 metres per m. and 10.69 calories for a slope of 0.13 metres (Amar).

In the descent, on the contrary, the expenditure was 5.50 calories in the first case and 4.53 in the second (Chauveaux fixed 52/100 the ratio of the expenditure between the descent and ascent in a vertical line. For the descent on an inclined way, with a slope of 13 cm. per metre, Amar found the ratio almost equal, but, with a gradient of 8 cm. the ratio was 85/100 for a man descending without load, and 75/100 for a man descending with a sack of 7.300 kg.

There exist, in addition, other secondary coefficients, of which the most important are the method of transport, the weight of the body, the muscular development, the freedom of movement, fatigue, food and the surrounding temperature.

The expenditure of energy varies markedly according to the method of transport (analysed in the article "Industrial Physiology").

According to Atzler the expenditure of energy in drawing a small truck on a level road is smallest when the man uses cords attached to both shoulders; it increases if the traction is effected by means of a cord pulled by the two hands; and it is still more increased if the traction is effected by a single cord attached to one shoulder. The energy expended in pushing a little truck on a level road is smallest when the man leans on his hands at the height of a metre from the ground; it increases if he leans at the height of half a metre; and is yet a little higher when the height of support is a metre and a half.

If a weight is raised with a windlass, the expenditure is at a minimum when the height of the handle is such that the man is able to keep the body erect; it increases if he has to hold his arms raised; and is still greater when the body is drawn together and bent.

In raising a weight, the expenditure of energy is at its maximum when the weight is raised directly from the ground; it is less if the load has to be lifted from a level at a metre from the ground.

Amar, Imbert and Crowden have made some interesting researches on the maximum strength developed by a man or a woman, and on the maximum load for transport by means of pulling or pushing (wheelbarrow).

The load should not exceed 150 kg. (Imbert) if the object is to avoid, or at least to attenuate, most pathological conditions, such as increase of pulse.
rate, respiration and arterial pressure. The best results are obtained when the load is balanced so that there is little weight on the arms, when it permits of good posture, and when the height of the wheelbarrow is adapted to the height of the individual (Crowden).

**Morbidity and Social Conditions**

For studying the social conditions and morbidity of porters, consideration is restricted to regular porters: porters on railways; at ports on quays, ships and barges; on rivers and lagoons when pulling and towing; and workers attached to the public transport agencies or the big markets. Type personnel of these services is usually disciplined by the local customs, or organised in associations and corporations regulated by special rules, approved by the authorities, except for those who work in the country and do so in an isolated and independent manner.

The mentality and social status of porters are generally of a quite low order, for the occupation is considered as very humble, almost contemptible and unworthy of a free man. Porters are usually of good muscular development, but of slow intellect (the bovine type of Taylor), and have no other qualifications than that of being able to furnish brute strength. Nor is it necessary that these men be of an athletic type, as might be expected according to the capacity for effort and for resistance which is required of them. Having observed that persons of the asthenic type were hardly surpassed by individuals in athletic development in daily work, Brodnitz and Grotjahn consider that the capacity for resistance does not depend on the power of the muscles, but on that of the ligaments. However, an enquiry of the Industrial Fatigue Research Board (1928) indicates the presence in workers of a certain proportion between the weight of the body and the total available strength; a coefficient of resistance exists below which there is inaptitude for heavy work.

Porters are, from the very nature of their work, compelled to eat much and, to take large quantities of drink, often alcoholic. It is also known that they spend frequently a large part of their time, which is not given to work or sleep, in the streets or open air, having as natural companions the lowest dregs of the social scale. But although the moral standard of these workers may not be high, porters — that is to say, those who are organised — do not seem to furnish a large contribution to crime.

Better economic conditions than those of certain categories of workers, and especially those of casual labourers, as well as a torpid psychology, contribute much to the avoidance of the strongest inclinations to crime.

Data on the morbidity and mortality of load carriers are almost nonexistent; official statistics usually confuse these workers with the large category of unskilled workers, or mix them with other categories of the services to which they belong, e.g. railways or maritime services.

Further, crude figures cannot have a great value, if the other conditions are not known; these are very variable from case to case, and include exposure to bad weather, long hours, weight of loads and kind of feeding. However, the morbidity and mortality are in general lower than those of numerous other industrial categories, which is certainly due as much to the rarity of any exposure to poisons or infection during work, as to the fact that this occupation is almost always carried on in the open air. The most complete information which is available deals with the morbidity of dock labourers (see articles "Boatmen", "Dock Labourers", "Seamen", etc.).

According to Mauro, the illnesses experienced by porters who during twenty years attended at the Milan Clinic for Occupational Diseases, were distributed as follows: respiratory diseases, 25.96 per cent.; gastro-intestinal disorders, 25.8 per cent.; rheumatic conditions, 19.5 per cent.; cardiovascular disorders, 14 per cent.; and tumours, 3.6 per cent. As regards the last three groups, porters come before all other workers.

As regards tuberculosis, the rate for this disease found among the transport workers of the Italian iron ore works is higher than that for other categories (Peri). It is also very common among the Chinese rickshaw coolies (Mazzolini).

**Pathology**

Carrying, such as involves heavy work, is sometimes continued without remission and often calls for rapid and strong muscular contractions (see article "Effort").

The body reacts first to these efforts by more or less serious symptoms or disorders of the circulation and respiration, following upon the more or less permanent contraction of the muscles and in particular; those of
the thorax and abdomen. The pulse rate may increase from 30 to 50 per cent.; the cardiac systole is prolonged from $\frac{3}{4}$ to 4; while the diastole is shortened from $\frac{1}{4}$ to $\frac{3}{4}$; respiration is increased to 25 or 25 a minute, while the vital capacity is lowered; and the temperature of the body varies from $\frac{1}{4}$ to $\frac{3}{4}$ degree (Amar).

Some almost identical changes after walking with a fairly heavy load have been found among officer cadets of the Frederick-William Institute who showed also symptoms of general stasis and in particular of the liver (Zuntz and Schumburg). A slight degree of hypertrophy of the heart, especially on the left side, of arteriosclerosis, and of pulmonary emphysema, especially marginal, have been noted among porters who carry loads on the head in Calabria, by Gabbii and Repaci. Gabbi has often found a fatigued heart among the carriers of kegs in Messina; Guffré has studied and clearly described the symptoms of fatigued heart among the fishermen of Siracava. Podkaminsky (1929) has recently contributed a radiographic study of porters' hearts.

Repercussions on the venous system, in the form of varicose veins or varices, are, on the other hand, somewhat doubtful among steel workers (Mazzolani), and porters of carrying-chairs in China (Mazzolani). Brodnitz and Grotjahn found 3.3 per cent. of varicose, 32.6 of serious varicose veins, 24.8 of slight varicose veins, especially on the left side, in the case of porters carrying sacks of flour.

No abnormal frequency, on the other hand, has been found by Vitali among the boatmen of Venice, nor by Diez among railwaymen and Post Office employees in Italy. Diez, while quite recognizing that varicose veins are not an occupational disease, considers that certain occupations are unsuitable for those with varicose veins.

Hypertrophy of the thyroid may also be considered as a consequence of circulatory disturbances. This has been found in young girls immediately after having commenced carrying weights on the head (Repaci, Fratini, Vidoni), as well as goitre, of which Mazzolani has observed 3 cases among 16 porters of chairs in China.

Hernia may be another pathological consequence of strain from carrying; it was found in the case of 14 per cent. of porters, especially those over fifty years, and weakening of tissues predisposing to hernia in 40.3 per cent. by Brodnitz and Grotjahn. Cases of movable kidney are not by any means rare.

Increase of the abdominal-thoracic pressure during lifting and carrying loads has been studied by Kaploune. By means of direct measurements on women, the ordinary type of respiration was found to be changed at the end of one to one and a half months, becoming principally diaphragmatic, and, during the lifting of weights over 20 kg., the intra-abdominal pressure increased, whilst it became lowered sharply and remained normal or almost so during the time of supporting the load. Lowering and a transient deviation of the body of the uterus has been noted. A comparative investigation by Kaploune on women porters and women workers other than porters has confirmed that the carrying of loads exercises an injurious influence on the genital organs of the woman. Women porters attribute a certain number of the disorders of menstruation, metrorrhagia, prolapse or simple falling of the uterus to their work; these affections were not only more important among the first than the second group of workers, but they occurred to a much higher degree among the first class of women after they had taken up the work of carrying loads.

Okuniewa, Steinbach and Schtlegowa have also reported disorders of menstruation in 60.5 to 78 per cent. of women porters, against 26.5 to 39.2 among other women workers. According to the early statistics of Conrad, women employed in carrying loads had 4.5 of stillbirths per 100 births compared with 2.1 for the rest of the population.

Changes in the body, consisting in permanent or transitory changes in the muscles and ligaments of the joints, constitute a second group of ill-effects due to the carrying of loads. The intervertebral fibro cartilages are crushed, which increases the normal curvature of the different segments of the vertebral column. The highest degree of flattening of the cartilages is met with in porters who carry on the head, because the vertebral column is then held in almost a vertical position. It should be mentioned that Gabbi and Repaci have observed a projection of the last cervical vertebra in women porters in Calabria.

The lower limbs also undergo such deformities as curvature of the femurs, genu valgum and flat foot. This latter is only seen in porters who work on flat or smooth ground, never in porters who work on rough ground.
The various changes in the formation of the skeleton naturally depend on the method of transport. When the weight falls on the line of gravity of the body or close to it, the deviations of the vertebral column appear chiefly in the form of kyphosis or lordosis. On the other hand, when the load is carried so that a crucial shoulder is held raised and this leads to dorsal scoliosis with the concavity directed towards the opposite side, with exaggerated raising of the costal arches of the same side and compensatory lumbar scoliosis. If, on the contrary, the load is carried below the shoulder, that shoulder is lowered and the dorsal concavity is directed towards the same side. The “scapulae alatae”, and an exaggerated development of the arms, in comparison to the height of the body, may be met with as a result of any of these methods of transport. The same thing may be said of flattened pelvis in women who carry water (Pen.)

These asymmetries and deformities are aggravated when the effort of carrying is borne by bodies which are still in the course of development. There may here be mentioned the early investigations of Giordano and Vasta, on children who carried sulphur (ca. rust) in the Sicilian mines (see article “Sulphur”).

There are methods used in transport which may cause the formation of a partial cavity in the region of the ribs and the sternum; such as the sub-clavicular fossa in boatmen of the Rhine, the Rhone and the lagoons, due to the application of the extremity of the oar to this part in order to move the boat along. In the same way, repeated pressure of hard substances on various parts of the body, especially on the back and shoulders, causes various and numerous bodily stigmata: atrophy, thickening and callosities of the skin, pigmentation, hypertrichosis, pseudo-oedemas (Levi-Bianchini), fibromata and lipomata, cysts and serous and mucous bursae; asymmetry of the acromion extremitv of the clavicle, due to carrying on one shoulder (Mori); slight hollowing of the bones of the vault of the skull and falling of the hair (Gabbi and Repaci); and deformity of the ear (Hisashi Okajima). Sometimes also this skin, after much irritation, becomes inflamed, and ulcerates in the parts on which the loads are carried.

Local pressure of hard bodies, and the muscular contraction it causes, is the cause of myositis (Devoto), neuralgia and muscular cramps — in the region of the neck and shoulder among porters who carry on the head, or on one shoulder; in the region of the arms when they are held up to support loads (Repaci).

Many diseases of the skin or mucous membranes are caused not by the actual carrying, but by the materials carried; dermatitis alatalis (Mori), which also caused an inflammation of the external ear (Coustan); or to cement (Papanti Pelletier); or to pyrites from Cyprus, which may also cause ulcers of the skin, blepharitis, conjunctivitis (Riedel), and sometimes nasal haemorrhages (Loriga); or to guano, basic slag, and manganese ore. Infestations by itch-mites (Pediculoides ventricosus) have been observed on various occasions among barley grain porters (Sherna, Engelbach, Levi). Among infections anthrax is important, occurring among unloaders of skins in the ports, and plague, due to contact with rats living or dead, or with their excrement in the holds of ships or in warehouses.

The use of such poisonous gases as hydrocyanic acid and sulphurous gas for disinfecting ships may be a source of serious poisoning among labourers unloading ships (Colombani, Rothfuchs).

The risk of accident must be also mentioned, especially among certain classes of porters.

According to Rothfuchs, the number of accidents among 18,000 persons employed in 1926 on transport or unloading work at the port of Hamburg, on the quays and ships, was 5,594 with 40 deaths: a percentage of 31, against only 14.66 found in the shipyards. The most common accidents are due to serious crushing of the abdomen; fractures, bilateral or multiple, of the pelvis; of the thorax or the limbs; and result from the fall of labourers into the holds, or the falling of loads on to the workers. According to Rothfuchs, other etiological factors of accidents are atmospheric conditions, especially humidity, cold and thin coatings of ice in the case of open-air workers; the engagement of fresh personnel not used to this special kind of work, as well as the abuse of alcohol, which is quite common.

Similar causes are found in the etiology of accidents among porters employed on constructional work or on the highways.

**Hygiene**

The principle which should underlie any hygienic measure in the transport
industry is that, as far as possible, the employment of man to do mechanical work should be avoided, and that, on the contrary, he should be used to control and concentrate the energy produced by other sources of motive power.

This principle to-day is largely applied in all organised transport services, in ports, railway stations, large industrial concerns, the construction of buildings and bridges. If it is not possible to use fixed or mobile mechanical devices, animals should be substituted for inanimate motive power; and, when it is necessary to have recourse to the strength of man, it is better from the hygienic point of view as from that of economy, since the energy-cost of the human motor is higher than that of other motors. Further, freeing man from carrying loads contributes to raise his personal dignity, for this labour of transport has always been associated in the mind of the people with the humiliating idea of servitude. It is merely necessary to recall the contemptuous signification that in all countries is attached to the term "porter", as well as other expressions which may be substituted for it, e.g. hatman, coolie, fatigue man, or common labourer, as well as the discussions on native labour which took place at the International Labour Conference in 1929.

Hence it was that the Seventh Italian Congress on Industrial Medicine welcomed a resolution by Peri and Loriga, demanding that legislation should be adopted prohibiting the transport of loads by man except in the case of absolute necessity. In any case, transport work should be work complementary to other occupations and not a definitive and exclusive occupation.

Where carrying loads by man cannot be avoided the ill-effects which may occur to the health should be prevented by limiting the maximum weight and the duration of carrying, as well as by improving the methods of transport.

An enquiry made by the International Labour Office, through the intermediary of the members of its Correspondence Committee on Industrial Hygiene, in 1926, showed that the weights of loads carried on men's backs in the principal European ports is still very high. This weight varies between 85 and 100 kg. in the port of Antwerp; between 100 and 120 kg. at Marseilles and Cardiff, and may reach 200 kg. for certain bales of flax in Belgium. The maximum weight permitted by regulation in the port of Genoa is 100 kg.; but it is often exceeded.

In Germany, weights of 100 kg. and over have been found in three-quarters of the industrial concerns; some sacks reached 200 kg. and, only a few years ago, sacks of potassium nitrate weighed even three hundredweights (Brodnitz and Grotjahn). In Great Britain the loads carried only a few years ago by the workers were 101 kg. and over; in the U.S.S.R., they vary from 80 to 160 kg. for stevedores on the Volga, and from 80 to 220 kg. for porters in Astrakhan. While recognising that these weights exceed by a good deal the physiological tolerance of the body, it must be said that it is not easy to fix a figure for a maximum weight which may be in complete harmony with the requirements of hygiene and those of working conditions, especially if the differences which exist in different cases be taken into account, such as the distances to be traversed; the slope and firmness of the ground; the height to which the load must be lifted; the frequency of the journeys; whether the return journey is without load; and the duration of the working day.

Loriga, in his report presented in 1914 to the meeting of the International Association for Labour Legislation, shows that, according to the researches of physiologists and experience largely acquired from work amongst soldiers, the limit of load physiologically bearable on a march along a level road, with an average hourly speed of 4 to 5 km., cannot much exceed a weight of 22 kg., if the carrying has to be continued for several hours a day and for consecutive days. Several reasons, however, do not permit of the strict application of this limit, which is recognised for soldiers, to stevedores; the latter carry loads for short periods, and enjoy thereafter a period of comparative rest which is at least as long, if not twice or three times as long, during the return journey without a load, and of rest while waiting or preparing to take other loads. But sometimes there must be taken into account aggravation caused by the frequency-
with which the effort of starting to walk has to be repeated; it has been calculated by Chauveau as equal to 2.50 per cent. of the static effort required to support the load; and also the much more considerable effort required by porters in loading and unloading.

The porter can diminish his energy-effort by regulating his step according to the weight, the distance to be traversed, and the irregularities of the ground, while a soldier must march in step; speaking generally, the load is better balanced than with soldiers, and, further, the majority of porters are usually stronger, better selected and more accustomed to the work than soldiers.

Circumstances being equal, the load of a stevedore may reach, without injury to his health, a weight of 60 kg., and be carried for a normal day of seven to eight hours, which includes the pauses and returning without load. But if the loads have to be transported to distances greater than 40 metres, or if the man must ascend steep slopes, or himself load the burdens, then the weight of the load or the daily duration of the work should be diminished (Loriga).

The trade unions have on several occasions demanded the fixing of a maximum weight. Their demands, which have been cited in the report already referred to of the International Labour Office, are that the maximum limits of loads should be fixed between 60 and 75 kg. It is this last figure which was taken by the International Labour Conference at Geneva in 1928 as the basis of discussion for the protection against industrial accidents of men employed in loading and unloading ships.

Hygienists encounter still greater difficulties when they try to fix the maximum weight for women and children. Cathechart, Bedale and Overton have tried to establish a relation between the optimum load and the weight of the body, by taking into account not only the ratio between the weight of the body in two categories, adults and women or children, and the surface of the body (as is done for the calculation of expenditure in calories to determine the food ration), but also the capacity for development of neuromuscular strength, and, especially of the need of preventing work from disturbing the rhythm of growth, and the functions of maternity.

In France, the Decree of 28 December 1900 fixed the limits of loads which may be carried by children, either on the

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Average weight of the body (kg.)</th>
<th>Maximum weight of loads (kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>29.2</td>
<td>14.7</td>
</tr>
<tr>
<td>12</td>
<td>33.0</td>
<td>16.5</td>
</tr>
<tr>
<td>13</td>
<td>36.6</td>
<td>19.3</td>
</tr>
<tr>
<td>14</td>
<td>41.8</td>
<td>20.9</td>
</tr>
<tr>
<td>15</td>
<td>47.9</td>
<td>23.6</td>
</tr>
<tr>
<td>16</td>
<td>52.7</td>
<td>26.3</td>
</tr>
<tr>
<td>17</td>
<td>57.8</td>
<td>26.9</td>
</tr>
</tbody>
</table>

In 1927 the International Federation of Transport Workers, and the International Federation of Food Workers, demanded that for young persons from sixteen to eighteen years the maximum limits for loads should be 50 kg., and that for women they should be fixed by legislation in the different States.

The limit of the working day during which a man can do carrying on his back is quite as important as the foregoing discussion. As a matter of fact, all the pathological manifestations which have been described as organic disharmony depend more on the duration of the carrying than on the weight of the load. However, this idea is not yet accepted by experts (see below, Legislation: Italy). There has also been a demand that, in the absence of legislative arrangements, candidates for the occupation of porter should be subject to a medical examination, as used to be done in the case of a man seeking employment as a porter in the French markets; this examination would be carried out chiefly to ensure that the circulatory and respiratory apparatus function regularly (Perl).

Very important hygienic results can be obtained by studying the technique of transport and the organisation of work; the use of tools and other apparatus to aid the work of man; conditions of firmness and safety of the ground traversed, such as bridges, foot-bridges and ladders; and also instructions specially laid down to avoid the ill-effects which may arise from some raw materials, capable of causing infections, poisonings and burns; or certain conditions of the atmosphere of the places of work, which may lead to asphyxia, or lack of light.

1 Reply from the Italian Labour Office to the Health Department of the town of Venice.
LEGISLATION

Australia, in South Australia young girls under twenty years are not allowed to lift and carry weights exceeding 13 kg.; in the State of Victoria this measure has been applied to young girls under eighteen years. In Spain children under sixteen years are not allowed to carry weights exceeding 10 kg., nor to draw or push loads representing a greater effort than that necessary to put in motion on a horizontal surface the weights mentioned in section 9.

In Germany (Bavaria) women are not allowed to carry loads in the building industry.

In the United States women are not allowed to lift a weight exceeding 30 kg. in California, or 11 kg. in the States of Ohio and New York — where, however, it is recognised that the weight is of less importance than the manner in which it is raised, the distance to which it is carried, and the effort and strain which it demands.

In Greece children under fourteen years are not allowed to carry loads exceeding 5 kg. and young persons under eighteen years loads of more than 10 kg. They are not allowed to draw or push loads over 300 kg. on small trucks moving on rails, or over 50 kg. on wheelbarrows.

In the U.S.S.R. it is illegal to employ at loading work boys under 11 years and women, and the maximum weight of packages which may be carried by a single person is limited to 48 kg. (3 poods). Beyond this weight, the separate work of loaders is prohibited, and the placing of the load on the back of the porter, as well as the lifting from the back of the porter, must be done by the help of other loaders. The maximum weight of load to be transported without machinery is 80 kg. (5 poods); beyond that wheelbarrows must be used; for loads above 480 kg. (30 poods) special machinery must be employed.

In some countries the Governments have laid down a list of the various kinds of transport work in which the limit of the load varies according to the age and sex of the persons employed. The regulations in force in some of these countries are given below:

Argentina.

Order of 15 October 1913 relating to the administration of the Act of 14 October 1907, No. 5291, regulating the employment of women and children 1.

Section 49. Maximum loads. The maximum weight that workers may carry both without and within the workrooms shall be:

(a) 10 kg. for boys under 16;
(b) 5 kg. for girls under 16;
(c) 10 kg. for women between the ages of 16 and 20.

Section 50. The maximum weight that may be drawn or pushed, including the weight of the vehicle, shall be as follows:

1 Cf. Annuaire de la législation du travail, 1913, Brussels.

(a) Trucks running on rails:

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Weight Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys under 16</td>
<td>300 kg.</td>
</tr>
<tr>
<td>Girls under 16</td>
<td>150</td>
</tr>
<tr>
<td>Women between the ages of 16 and 20</td>
<td>300</td>
</tr>
</tbody>
</table>

(b) Hand barrows:

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Weight Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys of 14 to 16</td>
<td>40</td>
</tr>
</tbody>
</table>

(c) Three- and four-wheeled barrows:

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Weight Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys under 16</td>
<td>35</td>
</tr>
<tr>
<td>Girls under 16</td>
<td>35</td>
</tr>
<tr>
<td>Women between the ages of 18 and 20</td>
<td>50</td>
</tr>
</tbody>
</table>

Chile.

Act No. 3915 of 9 February 1923.

Under this Act the weight of sacks containing goods of any kind which are to be carried by man power shall not exceed 80 kg.

Regulation No. 2494 of 27 August 1922 for the administration of the above Act state that a sack containing goods which is to be carried on the shoulder shall not weigh more than 80 kg.

Sacks not provided with handles may be dragged by young females if they do not contain goods likely to be damaged in this way, provided that an agreement has been concluded to this effect between employers and workers.

Sacks containing foreign goods which weigh more than the legal weight shall not be carried on the shoulder unless the weight is reduced to 80 kg. Sacks containing goods liable to increase in weight owing to damp or for other reasons shall be deemed to comply with the Act even if they weigh more than 80 kg.

France.

Decree of 28 December 1909, amended by the Decree of 26 October 1912, regulating the labour of women and children employed in industry and commerce (maximum loads which may be carried, dragged, or pushed by children and women).

1. Weights that may be carried.

Boys and men:

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Weight Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 14 years of age</td>
<td>10 kg.</td>
</tr>
<tr>
<td>Age 14 or 15</td>
<td>15</td>
</tr>
<tr>
<td>Age 16 or 17</td>
<td>20</td>
</tr>
</tbody>
</table>

Girls and women:

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Weight Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 14 years of age</td>
<td>5</td>
</tr>
<tr>
<td>Age 14 or 15</td>
<td>8</td>
</tr>
<tr>
<td>Age 16 or 17</td>
<td>10</td>
</tr>
<tr>
<td>Age 18 or over</td>
<td>15</td>
</tr>
</tbody>
</table>

2. Weights that may be moved in trucks running on rails.

Boys and men:

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Weight Limit (truck included)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age under 14</td>
<td>300 kg.</td>
</tr>
<tr>
<td>Age 14, 15, 16, or 17</td>
<td>500</td>
</tr>
</tbody>
</table>

Girls and women:

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Weight Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age under 16</td>
<td>150</td>
</tr>
<tr>
<td>Age 16 or 17</td>
<td>200</td>
</tr>
<tr>
<td>Age 18 and over</td>
<td>300</td>
</tr>
</tbody>
</table>
3. Weights that may be moved in wheelbarrows.

Boys and men:
- Age 14, 15, 16, or 17: 40 kg.
- Age 18 and over: 40 kg.

Girls and women:
- Age 18 and over: 40 kg.

4. Weights that may be moved on vehicles having three or four wheels, such as handcarts, etc.

Boys and men:
- Age under 14: 30 kg.
- Age 14, 15, 16, or 17: 60 kg.

Girls and women:
- Age under 16: 35 kg.
- Age 16 and over: 60 kg.

5. Weights that may be moved in two-wheeled handcarts.

Boys and men:
- Age 14, 15, 16, or 17: 65 kg.

Girls and women:
- Age 18 and over: 65 kg.

6. Weights that may be moved by means of tricycle carriers.

Boys and men:
- Age 14 or 15: 50 kg.
- Age 16 or 17: 75 kg.

Great Britain.

The Regulations of 3 January 1913 for the manufacture and decoration of pottery lay down that children and young persons under 16 years of age may not carry loads of more than 30 lbs.

The Woollen and Worsted Textiles (Lifting of Heavy Weights) Regulations, 1926, dated 18 November 1926, No. 1463, which came into force on 1 January 1927, the date on which the Order of 27 July was abrogated, fix the following maximum loads:

<table>
<thead>
<tr>
<th>Person employed</th>
<th>Maximum weight where material, yarn, cloth, tool, or appliance is a reasonably compact or rigid body</th>
<th>Maximum weight where material, yarn, cloth, tool, or appliance is not a reasonably compact or rigid body</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Man</td>
<td>1 lb, 150 lb</td>
<td>1 lb, 100 lb</td>
</tr>
<tr>
<td>(b) Woman of 18 years of age and over</td>
<td>65 lb, 30 lb</td>
<td>65 lb, 30 lb</td>
</tr>
<tr>
<td>(c) Male young person over 16 and under 18 years of age</td>
<td>65 lb, 30 lb</td>
<td>65 lb, 30 lb</td>
</tr>
<tr>
<td>(d) Female young person under 18 years of age</td>
<td>50 lb, 30 lb</td>
<td>50 lb, 30 lb</td>
</tr>
<tr>
<td>(e) Male young person under 16 years of age</td>
<td>50 lb, 30 lb</td>
<td>50 lb, 30 lb</td>
</tr>
</tbody>
</table>

The Royal Decree No. 520 of 14 April 1927 confirming the general regulations for industrial hygiene lays down in section 29 "special rules for the work of children, young persons, and women."

The weights to be carried by such persons when engaged in the transport of loads may not exceed the following:

(a) Weights to be carried by hand or on the shoulder:
- Boys under 15: 15 kg.
- Boys of 15 to 17: 25 kg.
- Girls under 15: 5 kg.
- Girls of 15 to 17: 15 kg.
- Women over 17: 20 kg.

(b) Weights to be carried on three- or four-wheeled handcarts on the level:

Eight times the above rates, including the weight of the handcart.

(c) Weights to be moved in trucks running on rails:

Twenty times the above rates, including the weight of the vehicle.

Women, young persons, and children may not be engaged in carrying loads for more than four hours per day.

Children and young persons under 18 years of age may not be employed in moving trucks.

Boys and girls under 15 may not be employed in the transport of loads on barrows or two-wheeled handcarts under dangerous or difficult conditions.

Pregnant women may not be employed in the transport of goods by any means after the sixth month of pregnancy.

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Prof. G. Loriga
(Rome).
Trinitrotoluene

(Tolite; Tolue; Triton; Trotyl; T.N.T.)

French: Trinitrotoluene. — German: Trinitrotoluoel. — Italian and Spanish: Trinitrotoluelo.

**Properties**

Formula: \(C_7H_5(NO_2)_3\) (CH)\(_3\). Trinitrotoluene (T.N.T.) is a stable substance, not affected by exposure to the air or to damp; it is solid at ordinary temperature; it occurs in the form of clear yellow crystals which are very slightly soluble in alcohol, but more soluble in fat solvents such as ether, sulphide of carbon, acetone and benzol. It melts between 80° C. and 112° C., according to the isomers present; in the pure state it melts at 81.5° C. and solidifies at 88.5° C. With a rise of temperature it ignites and burns with a very smoky flame. When melted and hardened again, it can be sawn and filed without danger. It is less sensitive to concussion and blows than picric acid. Its combustion causes a sudden shock, which gives rise to a violent explosion. It is affected by light, which causes a superficial change in colour veering towards dark brown. It is without smell and has a bitter taste. It colours the skin, hair and nails yellow, but this coloration disappears when treated with a mixture of “water-glass” (the product which results from the reaction of silicic acid upon soda) with Glauber salts and alum.

**Industrial Operations**

T.N.T. is obtained by nitrating toluene (see that article) generally carried out in three stages; first, toluene is converted into mononitrotoluene and then into dinitrotoluene. The mono can be transformed directly into trinitrotoluene, but the preparation by three stages gives the best results.

The toluene is heated, keeping the temperature steady at 30°-40° C. in a nitrating apparatus of cast iron, furnished with a mechanical stirrer; a mixture of sulphuric and nitric acids is then slowly added while stirring during half an hour at a temperature of about 50° C. The mononitrotoluene which forms as oil in the upper part of the solution is decanted and washed with water. The product so obtained is added to a sulfo-nitric mixture in a nitrating apparatus and stirred till a temperature of 90° C. is reached. At the end of an hour’s reaction at this temperature, dinitrotoluene forms and is decanted.

If the nitration is effected by putting the mono into a bath containing mother liquor from a preceding process of trinitration, the dinitrotoluene obtained contains 10 per cent. of trinitro. T.N.T. is prepared by dissolving dinitrotoluene in sulphuric acid of 100 per cent. strength in a nitrating apparatus and heating the mixture to 60°-65° C. Next sulphonitric liquor is added in such a way that the temperature is maintained at a fixed degree which however varies according to the different phases of the reaction. Finally, sufficient water is added to weaken the acid to 60° B.; at this stage there occurs precipitation of the greater part of the product in solution. It is then reheated to 90° C. and decanted.

Nitration may sometimes be effected in a single process and trinitrotoluene obtained directly by starting with mono mixed in a nitrating apparatus with sulphuric acid at 66° B. It is then heated to 80° C. and dry nitrate of soda is gradually added until a temperature of 120° C. is reached, which should be maintained for an hour and a half. It is then allowed to fall to 90° C. and the process is terminated as above.

The T.N.T., after being washed in water at 85°-90° C. to remove the acid, is decanted afresh and washed a sufficient number of times. Purification can be further effected by mixing trinitrotoluene with alcohol at 92°. It is then passed through a filter press, but it can also be digested by sulphuric acid at 66° B.

When the melted product is completely neutral, it is poured into cold water, where it solidifies in the form of granules.

**Crystallisation**

In other factories the products derived from the nitrating apparatus are decanted into crystallising vats supplied with large hoods. The acids are deposited and there forms upon the surface a crust of crystallised trinitrotoluene, which is then broken up and put into the washers. The splashings which crystallise upon the inside of the hoods should also be broken up.

The fragments of T.N.T., after crystallisation, are piled into large boilers where they are washed with hot water.

The product, sorted in a large apparatus which empties on to a sieve, is sifted and then packed by hand in barrels lined with paper.

**Uses**

T.N.T. is used for filling shells, and for making detonators and fuses. Shells and grenades are filled with
pure T.N.T. or with amatol, which is a mixture of T.N.T. and ammonium nitrate containing 20, 40 to 60 per cent. of T.N.T., either melted or in powder. The T.N.T. is melted, purified and, if necessary, moulded, moulded and compressed into the shells.

The powder is ground in mills, weighed and put in a hydraulic press. The compressed charges are then trimmed upon a lathe, generally in a compressing room, and plunged into melted paraffin and wrapped in varnished paper. These last processes are generally carried out by women in different rooms to those used for compression or trimming. The charges are then weighed by inspectors who scrape through the paraffin if they are too heavy and peel off with a knife or chisel the quantity of T.N.T. required to obtain the correct weight. The charges are more often moulded than compressed. The T.N.T. is melted in cauldrons which must be fed and supervised. Ladies are often used for charging. T.N.T. debris is sometimes melted in open cauldrons. When the workmen draw the T.N.T. from tubes or receptacles, a certain amount may fall upon the ground and should be cut up and swept together when it has solidified. The melted T.N.T. is run into the shells. If any falls outside the shells, it should be scraped away with pieces of pointed wood or bronze knives, the fragments being removed by brushing and ventilation. This can be avoided by putting round the shell a paper wrapping kept together by an India-rubber band, or by introducing the T.N.T. by means of a steel funnel, so as to pour in the quantity required to fill.

A third method consists in pouring melted T.N.T. into moulds and withdrawing it when it has cooled and hardened. It is then drilled, smoothed, and coated with paraffin, its consistency being that of maple sugar. The solid T.N.T. is drilled for the insertion of the detonator into the shape of the opening of a pointed arch. The thread of the screw in the opening of the shell is cleared unless it has been covered during the operation of filling. The shell is then cleaned and polished. Imperfect shells with defective mouths should be emptied; this is sometimes done by plunging the shells into a reservoir of hot water and allowing the charge to become sufficiently warm to melt.

Other operations carried on in the charging factories are: the filling of bags, made of vaselined silk, and the application of a covering of wax to the shells.

Sources of Risk

During Manufacture

Danger arising particularly from the inhalation of fumes does not constitute a serious occupational risk, if no accident occurs such as an overheating or a leakage when adding the acids. Danger from dust is equally to be guarded against, but to a less degree, in certain processes. Nevertheless it is desirable to emphasise that the dry powder of T.N.T. gives off fumes even at a temperature as low as 32° C. All the processes are liable to be sources of danger. The troubles which arise in the course of nitration have been sometimes attributed to the presence of phenyl nitromethane, C₆H₅CH(NO₂)₃, due to the acid being too dilute in the first phases of the process. Crushing and shovelling do not cause much dust for the material is moist and sticky. The troubles caused generally by this process are due to volatilisation at the ordinary temperature of dinitrotoluene if it is present, or to the handling of the product (which should be avoided).

On the other hand, sorting, sitting and packing are dusty processes. The material gets into the atmosphere of the workshop and is deposited upon the floor, the apparatus, clothes, etc. There is then risk of poisoning by inhalation of dust.

During Use

The risks are greater in the factories where shells, grenades, etc., are filled than in the manufacture of T.N.T. The degree of poisoning is slight in the process of making compared with that of filling. Out of 182 cases, with 52 deaths, which occurred in 19 filling factories, and 6 factories where T.N.T. was made, only 7 cases, none of which were fatal, occurred in the latter.

The filling of shells by pressure causes during manipulation much fine dust which remains in suspension in the atmosphere and adheres to the skin and to the clothing. The workers, even if wearing gloves, get their hands stained a brilliant yellow. Where T.N.T. is ground the workers are covered with dust and large quantities of amatol are scattered on the floor causing dermatitis of the feet and ankles. The packing of paraffined charges and outside varnishing are harmless processes, as the T.N.T. is covered over. But the paraffining and inspection present some risks due to exposure to dust in the course of manipulation. Poisoning occurs even if
the workers wear gloves. In the filling factories the danger is greater, for it arises from the fumes rather than the dust of T.N.T. (the melting cauldrons being allowed to be open). It is the same with fumes set free in the course of washing and shovelling. Moist heat increases the possibility of poisoning, but not of dermatitis which is more common in summer owing to the greater surface of the body exposed.

T.N.T. is supposed not to volatilise below 180° C., but at lower temperatures it is quite possible to find perceptible fumes about the cauldrons. The air in the melting rooms analysed by Philips and Casselmann (United States) contained about 0.006 mg. per litre, so that a worker during 7½ hours' work, inhaled 16 mg. of T.N.T.

Filling the cauldrons is also dangerous on account of the setting free of dust. The worker in charge of this operation has to watch the cauldrons and add T.N.T. from time to time. The cauldrons are usually filled by using scoops, but small quantities of dust arise each time.

Fatal cases of poisoning have occurred during stirring, which should always be carried out by mechanical means. By cleaner methods of work or the use of more adequate methods of filling, it is possible to prevent T.N.T. falling upon the floor and the tables.

The third method of shell filling (see above) does not present any great risk, as the charge sets free very little dust, on account of its consistency. Nevertheless a high rate of sickness indicates absorption by the skin in the course of handling. In that case the danger may be due to dinitro, which is more easily absorbed and is contained in the raw T.N.T. used.

After the filling, danger from fumes disappears, but that due to dust always remains. The cleaning either of the screw thread at the mouth of the shell or of the hole for the detonator by means of narrow brushes for removing dust is a dangerous process. The cleaning of the detonator hole has been carried out in one factory by aspiration. The emptying of rejected shells is a very dusty operation when the extraction of fragments is carried out by means of compressed air. The method of immersion in warm water is much to be preferred.

Some cases of sickness have occurred among workers occupied in filling bags with T.N.T., or grenades by hand with ammonal, in tying them with vaselined string, or again among those occupied in the following processes: sifting by hand, or accessory processes, such as handling trays covered with dust used for carrying the T.N.T. from the magazines to the workrooms.

TOXIC ACTION

T.N.T. can get into the system in three ways: (1) by inhalation of fumes or dust, (2) by absorption through the skin, (3) by ingestion. The chief way seems to be by the skin (according to English writers) and by the respiratory passages (according to Americans). It seems, however, that there are quite remarkable differences of sensibility among individuals attributed to differences of the permeability of the skin, just as the method of poisoning is also variable. According to Lehmann, poisoning by fumes is little to be feared, for they are only slightly diffused in the atmosphere. As a matter of fact while those inhaling fumes of T.N.T. suffered sickness, the proportion of 1 per cent., those who handled the product were sick in the proportion of 10 per cent. and those who handled it with greasy hands (fasteners of bags, cleaners of benches and moulds with oily dusters, and workers who handle lard to grease grenades) in the proportion of 17 per cent. Oily substances seem then to favour the absorption of the poison.

T.N.T. passes through the tissues without being modified and is eliminated by the urine in a modified form (see Symptoms and Diagnosis).

The brown colour of the urine is due to a product of oxidation of T.N.T.; it can be seen without the addition of a reagent and is of great value as a means of detecting trouble. The spectroscope shows haemochromogen in the urine.

The blood of poisoned animals is brownish and contains trinitrocresol and alkaline haematin.

Before the war P. White and Hay (1907) regarded T.N.T. as non-injurious. Nevertheless they had noted that with cats 3.5 cc. and 5.3 cc. of a 1 per cent. solution of T.N.T. caused a slight cyanosis. As regards man, Lewin held that a quite appreciable quantity of poison was necessary to cause trouble. Escaler reported that T.N.T. does not give rise to serious illness either in the process of making or its use. But during the war its use rather than manufacture caused numerous cases of illness of which many were fatal. On the researches of Moore and his colleagues was based the opinion that T.N.T. is absorbed by the skin. In 1921 Haythorne, carrying out experimental work, found with rabbits and guinea-pigs poisoned by the cutaneous
or gastric paths lesions of the liver similar to those seen in jaundice in man: methaemoglobin in the urine in the last stage of poisoning; grave anaemia of the hyperplastic type; fixation for quite a long period of T.N.T. in the tissues. A dose of 5 to 100 mg. per kilogram of the animal causes variable symptoms. In reality with 5 mg. clinical symptoms do not always occur and the dog, like man, shows a very variable individual susceptibility. Moreover, a definite tolerance for T.N.T. has not been confirmed.

According to Moore and his colleagues this substance is reduced in the system to 2-6 dinitro-4-hydroxylamino-toluene, which in its turn is transformed to a dinitro-4-nitroso-toluene. The derivative of hydroxylamine combines with glucuronic acid and is eliminated in this form. The products of reduction have the same action as T.N.T. But up to the present it has not been determined what is the derivative which exercises a poisonous action, or if there is more than one product involved in the disturbances which have occurred in the stomach, liver, kidneys and the bone marrow.

English and American authors consider that T.N.T. is a very virulent poison, but that the impurities which it may contain are not poisonous. They base their opinion on the fact that both pure and raw T.N.T. are shown by experiments on animals to be equally poisonous. According to Stewart the poison acts slowly upon the liver cells, even when the patient is absent from the dangerous work which exposed him to the absorption of the poisonous substance.

The toxicity is attributed by other writers to other poisons which are impurities of T.N.T., especially to dinitrobenzene and to tetrinitromethane which are found in pure non-crystallised T.N.T. Tetrinitromethane, which even in the smallest fractions produces effects, exerts an especially irritating action on the mucous membranes. This opinion is prevalent in Germany where Koelsch, relying upon experiments upon animals and upon his own experience, declared (1917) that T.N.T. is a product relatively slightly poisonous in comparison with nitrobenzenes, and that only exceptionally, among predisposed individuals occupied for prolonged periods under special conditions, such as dirt, insufficient food, alcoholism, and defective apparatus, T.N.T. can cause poisonous symptoms, which are usually confined to the blood, with anaemia, and the formation of methaemoglobin. The comparatively slight danger can be overcome by adequate precautions.

It is necessary to mention at this point that the action of T.N.T. has been different in Germany and in Great Britain, so that whilst in Germany it has generally exercised an irritant action upon the skin and is slightly toxic, in Great Britain, according to Fischer and Koelsch, T.N.T. contains a greater quantity of impurities (especially tetrinitromethane). Generally speaking, the derivatives of the distillation of tar in Great Britain are more injurious than those obtained in Germany, e.g. the frequency of dermatitis and of chimney-sweeps' cancer.

In Great Britain a predisposition to diseases of the liver has been noticed, perhaps due to diet. A certain number of workers seem to be immune to the poison, and others who show slight signs of poisoning on commencing work seem to acquire immunity or not to be liable to react to the poison with serious symptoms. Nevertheless there are yet doubts on this last conclusion. It is admitted generally that T.N.T. is poisonous for a minority of workers who come in contact with it. Fat persons are apparently more susceptible and more frequently victims of serious poisoning and fatal results. Negroes are very slightly susceptible to dermatitis and perhaps to poisoning, but the last point is not proved.

**Statistics**

**Germany.** — Up to 1917 only 50 cases of acute atrophy of the liver had been reported, occurring especially among young men, aged 16 to 26, and women. In a factory at Potsdam which employed in 1916 an average of 143 men and 380 women, and 340 men and 620 women in 1917, the following cases were recorded:

<table>
<thead>
<tr>
<th>Disease</th>
<th>Year</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dermatitis</td>
<td>1916</td>
<td>11.7</td>
<td>9.7</td>
</tr>
<tr>
<td>Ditto</td>
<td>1917</td>
<td>7.3</td>
<td>10.5</td>
</tr>
<tr>
<td>Respiratory diseases</td>
<td>1916</td>
<td>10.3</td>
<td>10.5</td>
</tr>
<tr>
<td>Ditto</td>
<td>1917</td>
<td>16.5</td>
<td>18.7</td>
</tr>
<tr>
<td>Digestive troubles</td>
<td>1916</td>
<td>28.7</td>
<td>28.7</td>
</tr>
<tr>
<td>Ditto</td>
<td>1917</td>
<td>16.5</td>
<td>18.7</td>
</tr>
<tr>
<td>Respiratory troubles</td>
<td>1916</td>
<td>1.4</td>
<td>20.5</td>
</tr>
<tr>
<td>and blood changes</td>
<td>1917</td>
<td>1.4</td>
<td>27.4</td>
</tr>
</tbody>
</table>

The dermatitis was really due to picric acid and the respiratory affections to T.N.T.

Up to the end of 1917, 7 serious cases were reported in a munition factory, 2 of which were women; in 1918, 4 cases.

**Bavaria.** — During three years Koelsch did not observe any fatal case and very
few specific injuries. But in 1918 he noted
19 cases of poisoning of which 1 was fatal. The compulsory notification start-
ing from January 1915 up to the end of
the war furnished 1,000 definite cases of
poisoning by nitro-compounds (dinitro-
benzene, tri- and dinitrotoluene, nitrated
naphthalene, trinitro-anisol, trinitrophe-
nol).
United States. — During 20 months in
one munition factory 7,000 cases of pois-
oning were recorded, of which 105 died.
During seven and a half months 17,000
cases of poisoning were reported, of
which 475 died. Harrington in 1917 also
reported numerous cases of poisoning.
All statistics furnished, however, present
the disadvantage of difficulty in establish-
ing which of the nitro-compounds has
been used, more especially as mixtures
are very often employed.
As regards the sickness and deaths
which occur in the melting and pressing
departments, where the product handled
was amatol, the following statistics are
given:

<table>
<thead>
<tr>
<th>Department</th>
<th>Number of cases reported</th>
<th>Number of fatal cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Men</td>
</tr>
<tr>
<td>Melting</td>
<td>40</td>
<td>29</td>
</tr>
<tr>
<td>Pressing</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Crushing</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>47</td>
</tr>
</tbody>
</table>

In 1927, Fortescue reported cases of pois-
oning amongst men engaged in the trans-
porting of charges of T.N.T. explosives
from a warehouse to a vessel. In spite of
the use of protecting gas masks, measures
of cleanliness (baths), medical supervision
and alternation in the operations, more
than half of the workers showed slight
symptoms of absorption of T.N.T.

Great Britain. — T.N.T. was slightly
used before the war and did not cause
poisoning. It had even been proposed to
replace dinitro by T.N.T.

During the war, however, its use more
than its manufacture brought out new facts.
As early as January 1915 in a T.N.T. fac-
tory there had been reported 6 cases of
poisoning with jaundice and a group of
pathological features resembling those
found in poisoning by tetrachlorethane,
i.e. lesions of the liver and kidneys. Two
other cases were reported in August and
December of the same year.

In consequence of these cases poisoning
was made compulsorily notifiable from
1916. Livingston, Learmonth and Con-
ningthorn described 36 cases in a single
factory in 1916; Panton in 1917 reported
50 slight cases among workers while
carrying on their work; Stewart, 14 cases
of jaundice. Out of 50,000 workers in con-
tact with T.N.T. a sickness rate of 3.8 per
cent. was noted from January 1916 to
August 1917, with a percentage of deaths
of from 0.9 to 1 per cent. From 1916 to 1923
the number of cases notified was 382, of
which 181 (32 fatal) were reported in 1916;
189 (44 fatal) in 1917; 4 in 1918; 3 (all
fatal) in 1919; no known case in 1920 and
1921; 2 in 1922; 3 in 1923, 1 in 1926, and
another in 1929.

Italy. — In 1915 the workmen employed
in an explosives factory suffered from
headache, cyanosis and cardiac troubles.
Small quantities of wine caused giddiness
and headaches, and aggravated the sym-
toms of poisoning.

Netherlands. — In 1917 a fatal case was
reported and numerous cases of conjuncti-
vitis and loss of strength. In 1918, when
supervision had been organised, there
was not a single case of jaundice.

Symptoms

An examination of 50 cases of poison-
ing by T.N.T. has enabled the Ameri-
cans, Putnam and Hermann, to tabu-
late the symptoms.

Quite, a long latent period often
precedes the illness, which sometimes
makes it appearance after 7 to
9 months after cessation of work.
Serious cases are not common, and
for one serious case there are about
30 slight cases.

The prodromal troubles are: symp-
toms of irritation such as sneezing,
coryza, epistaxis, and watering of the
eyes, but especially a chronic cough
which is not explainable by any known
cause; sometimes the workmen com-
plain of catarrh and dryness of the
throat. Unusual dyspnoea is also
present, a feeling of fatigue not
explained by overstrain, and sudden
violent pains in the legs and feet.

There have also been noted headache,
a feeling of intestinal discomfort,
burning sensations, a bad taste in the
mouth, anorexia, spasmodic epigastric
or sternal pains, nausea, vomiting and
acid eructations. There is constipation
followed by diarrhoea which produces
a very marked toxic condition.

Sometimes in the early days cyanosis
is observed. The toxic stage is marked
by troubles sometimes slight (derma-
titis, gastritis) and sometimes serious
(anaemia, jaundice).

Dermatitis due to the local action of
T.N.T. and attributed to its combina-
tion with ammonium nitrate is very
common. The skin and hair present
a yellowish colouration, especially
marked on the hands, where it is
distinctly yellow. The clothing and
linen may on the contrary be some-
times coloured red. A diffuse erythema
appears with symptoms analogous to
those of urticaria and attacks prin-
cipally the back of the hands and
wrists. This erythema may attack
similarly the face, neck, feet and
ankles (when the floors of the factories are dusty) and the genitals. The wearing of respirators, through mechanical action, soon causes lesions around the mouth. The lesions set up an unbearable itching with a rash, and a sensation of burning, often followed by exanthemous lesions which do not respond to treatment at all easily. At a more advanced stage vesicles which cicatrize with a scab are noticed at the flexion folds and between the fingers. On the face the lesions take a papular form, but often lichen or secondary infections are seen.

Dermatitis, which occurs more frequently in the processes of sifting, weighing and packing, is often seen in the course of the first week's work, at the end of which immunity seems to be established. When it persists it is necessary to take the workmen off work.

Gastritis, which usually appears in the first week of work, is caused by irritation arising from swallowing dust of T.N.T., to which the stomach may respond to treatment at all easily. This form is characterised by morning vomiting after taking food, anorexia and salivation. A toxic form of gastritis is due to absorption of T.N.T. by the skin. It is rarely associated with dermatitis, but accompanies other symptoms of poisoning, such as cyanosis of the lips, restlessness, depression, epigastric colic, nausea, and abdominal distension.

Anaemia, which seems to be a pathological condition independent of jaundice, is very common. It is associated with dyspnoea, severe chest pains and cyanosis. Among 100 women taken at random in a T.N.T. factory, 78 were cyanosed and 18 showed a marked cyanosis. A pulse as low as 48 has also been noted (Koelsch). In serious cases petechial haemorrhages were observed. Menstrual troubles are common with women.

The formation of methaemoglobin detectable by the spectroscopic has been noticed as a blood change. According to Litsche it is formed by the reduction of T.N.T. into a hydroxylamine derivative which acts upon haemoglobin transforming it into methaemoglobin.

The first observations were not very accurate and the toxic action of T.N.T. was only admitted by analogy with that of D.N.B. and D.N.T. (Malden, Hudson). Following upon an investigation of 50 workers, Panton formed the opinion that the daily absorption of T.N.T. did not have an injurious action on the blood (4 cases of blood changes out of 28 examined); but Stewart, on the other hand, found 14 cases of serious blood changes. Smith supports the opinion of Panton, basing his opinion upon the negative result of his researches (slight cyanosis). According to 235 examinations of blood made at random in 1910 upon 100 cases of poisoning from various departments of eight factories, Minot found that in 83 per cent. of the cases there was polychromatophila. But whereas the number of red corpuscles, the haemoglobin value and the colour index were generally little altered, the number of white cells was increased and the formula variable, for varying with the cases there were noticed neutrophile leucopenia, neutrophile leucocytosis and lymphocytosis (sometimes the most frequent change is eosinophilia).

Voegtlin, Hooper and Johnson in 1920 examined 237 workers and found 72.5 per cent. with anaemia of varying degree, but only one case with severe anaemia. Among 18 per cent. of those with anaemia, anisocytosis and poikilocytosis were quite marked; in 4 per cent. leucopenia; in 22 per cent. leucocytosis; and in 4 per cent. lymphocytosis. Forty-eight per cent. of those with anaemia had also cyanosis and about 75 per cent. of the workers examined showed premonitory symptoms of poisoning. When the anaemia reaches a certain degree the prognosis is fatal.

Toxic jaundice is less frequent than gastric poisoning, which it does not seem to follow; it is due to the action of T.N.T. upon the liver. There is very often a latent period between the cessation of work and the onset of sickness due, perhaps, to continued absorption by the skin, where it acts as a kind of reservoir of the poison, or to absorption from the hair or soiled clothing. This latent period may vary from 3 days to 17 months, but jaundice usually appears at the end of 3 months. In England 83 per cent. of the cases have been reported as occurring between the fifteenth and sixteenth week, and out of 105 cases not one occurred before the fourteenth week.

The onset of toxic jaundice is often sudden, but may perhaps be preceded by symptoms such as somnolence, giddiness and depression. When the condition has developed, jaundice appears with marked diminution of the liver and ascites, abdominal pains and constipation. The urine contains biliary salts and pigments, albumen and sugar with intermittent glycosuria; the reaction of Webster is positive. The illness is a long and serious one which may last several months, leav-
ing the patient with a liver irreparably damaged. There is a fatal issue in from 25 to 30 per cent. of cases. If the prognosis is fatal, coma occurs generally at the end of three weeks. Among the conditions reported, nerve symptoms are prominent, such as fainting, loss of consciousness, vertigo, apathy, amnesia, inco-ordination, troubles of vision, peripheral neuritis, and cramps; when the illness passes on to a fatal issue delirium and coma develop.

**Diagnosis**

At the onset the diagnosis is often difficult, for serious cases sometimes develop without any premonitory symptoms to which any importance can be attached, while typical symptoms which persist a long time characterise cases which are neither fatal or even serious. When the typical symptoms of absorption do not appear, diagnosis must be based especially upon the detection of T.N.T. in the urine (reaction of Webster), which may be made in the early stage of absorption. To 12½ c.c. of urine add 12½ c.c. of a 1/5 solution of sulphuric acid and 10 c.c. of ethyl ether. Shake, decant, wash with 25 c.c. of water. Decant and add 5 c.c. of a 4 to 5 per cent. alcoholic solution of soda or potash. If T.N.T. is present a purplish pink colour is seen, the depth of the colour increasing in proportion to the quantity of T.N.T. present. This colour passes quickly to brown. The transitory purple colour is what must be taken into account. This reaction, which shows in the absence of any clinical symptoms, indicates absorption and elimination of T.N.T. Taken in conjunction with symptoms of onset it is sufficient indication to take the worker from dangerous work. This reaction is found from the first week of work and continues long after the contact with the poison has ceased. In acute cases of poisoning it is noticed that the reaction gives a negative result, which shows without doubt that elimination of T.N.T. has not taken place.

**Hygiene**

It is practically impossible to avoid contact with T.N.T. during industrial operations. As a matter of fact it is not possible to prevent quantities of poisonous fumes from being liberated when the product is heated, or dust or solid or liquid material falling on the floor or on apparatus and then being diffused through the atmosphere of the workshop. Further, the fumes condense in fine dust and aggravate the danger of poisoning. Prophylaxis must then be rigorous and ensure that fumes and dust do not soil the worker and his environment.

Machines or mechanical devices should be used which should be provided with exhaust draught for effectively removing fumes and dust.

The poisonous fumes being heavier than air, adequate ventilation demands that the inlets for air be at the top of the room, with exits at the level of the floor. The air on entering should be warmed in winter, cooled in summer and distributed so as not to raise any dust. The ordinary metal types of ventilators cannot be used on account of sparks which are caused by friction and may give rise to explosions.

All liquids setting free fumes should be put under ventilating hoods. Covers for closing the receptacles are useful, but insufficient, for there must always be some opening in order to carry out the necessary processes of filling, mixing, and inspection; hence it is essential to have additional apparatus for withdrawing the fumes. Respirators are inefficient and even dangerous, for dust accumulates upon their edges or on the skin, and, through pressure, often causes ulceration of the face.

On the contrary, breathing apparatus is useful, especially in case of large quantities of fumes being set free owing to accidents during work, or for repair work which necessitates entering receptacles and reservoirs. Adequate protection of the skin should be provided for when there is dust or it is necessary to handle the product.

Nitrating ought to be carried out in separate places which are spacious, well ventilated, and provided with easily accessible exits. The nitrating cauldrons must be hermetically closed and tanks of water arranged so that in case of need the mass undergoing reaction can be run into them. No nitrated product should be stored or handled in the nitrating room. The acids should be mixed in receptacles placed in the open air and roofed over. The washing must be carried out in buildings where no nitrated product is stored.

Recrystallisation should also be carried out in isolated departments. All the receptacles containing solutions should be so closed that the fumes are not able to escape into the atmosphere. Hand work and all contact with the products during the processes of crush-
ing and shovelling should be forbidden. Stirrers, at least two metres in length, should be used for breaking up the crystallised mass. The drying ovens must be ventilated in such a way that the hot air coming from the ovens passes into the outside air; the crystallisers must be provided with ventilating hoods so that evaporation can take place; workmen employed in sorting, sifting and packing should be supplied with india-rubber gloves and boots. All the preventive measures laid down for the storage and handling of inflammable solvents and explosive substances must be strictly observed.

In the process of melting T.N.T. for charging projectiles, energetic exhaust ventilation must be carried out; cauldrons must be closed except during the time necessary for the process of charging; the solution must be mechanically stirred; and an additional ventilating system must be installed where the melted product is withdrawn. All filling machines should be well protected by ventilating hoods or cowls. A double cowl, one part external for the raw powder and the other internal for the fine powder, has been tried with good results. The dust is removed to dust chambers and dissolved in water. Careful supervision of the system of pipes must be made to ensure that no dust escapes, as this is a source of danger and of serious illness.

The dust caused by boring should be caught in closed receptacles.

Although some experts consider that the use of gloves and overalls may have no practical value, it will be well to make sure they are provided, together with changes, as well as being regularly washed. It has been proposed to employ special varnishes for the hands, but their use has not given good results in Great Britain. In order to remove T.N.T. from the skin, a good washing does not suffice and it is necessary to employ either a 10 per cent. solution of sodium sulphite or of acetone. Alternation of work reduces the period of exposure. In one German factory the team had a shift of four hours. T.N.T. being rapidly absorbed (but according to certain experts being as rapidly eliminated) it is best to avoid overtime and to give leave of absence during the week so as to avoid any accumulation of poison in the system. These measures are particularly necessary in hot weather, which raises the rate of sickness if adequate precautions are not taken. Medical inspection on engagement will provide for the exclusion from work of predisposed individuals and especially those with anaemia, those who perspire too freely, alcoholics and those with diseases of the liver and respiratory passages.

Periodical medical examination, either weekly or fortnightly, of workers is very important in practice. It enables the removal of workers brought into contact with the poison to be carried out at the commencement of the poisoning. In one American factory where a strict supervising medical service had been organised, no fatal case occurred, or any case of serious toxic jaundice during six years, which shows that adequate precautions will render the risk almost negligible. Nevertheless, periodical examination with early withdrawal of workers, drafting them to other work, will only be beneficial if the skin is completely cleansed of T.N.T. and the soiled clothing is changed. It is important also to have good food, for the poison acts more readily if the stomach is empty. The distribution of milk before the commencement of work, which was compulsory during the war in the English shell-filling factories, was based upon the fact that improved nourishment provided by the management for women who had been hitherto badly nourished diminished the sickness rate.

Workers should be instructed upon the dangers connected with their work and the means of combating them, as well as the measures to be taken in case of sudden illness.

**LEGISLATION**

As regards the employment of women and children the rules laid down for explosive factories in general are applicable. Exclusion of young men of less than 18 years and of women has been adopted owing to cases of serious danger from poisoning and on the advice of the inspectors of factories. Periodical examination is compulsory in Great Britain. In Holland the visit has been arranged in agreement with the heads of establishments.

Compulsory notification had already been adopted in Bavaria in 1915, and is in force in Great Britain, Holland, and generally in the countries where there is compulsory notification of poisoning by nitro and amido derivatives of benzene (see that article). Compensation is provided for in British Columbia, Great Britain and Switzerland. In Germany an ordinance, dated 12 October 1917, provides that fatal cases of T.N.T. poisoning are to be considered as accidents as regards legal compensation.
TRIOXYBENZENE

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Trinitroxyylene
(Trinitroxyylol)

Of the three isomeres, meta-trinitroxyylene, used in modern technique, has been studied experimentally by Ilzhofer, who has come to the conclusion that this product is even less poisonous than other nitrotoluenes.

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Trioxybenzene
(Trihydroxybenzene; Trivalent Phenol; Pyrogallic Acid; or Pyrogallol)


Trioxybenzene (formula: \( C_9 H_6 (HO) \)) (1,2,3) is obtained by heating gallic acid in an autoclave with two or three times its weight of water at 200° C. for half an hour. The acid loses a molecule of carboxylic anhydride and gives pyrogallol or pyrogallic acid which melts at 131° C. and boils at 231° C.
It is purified by decoloration with animal charcoal and by crystallisation or by sublimation.
In industry it is also prepared by distillation of gallic acid mixed with pumice stone in a current of carbonic anhydride, or by making alkalies react upon a dihalogen derivative of phenolsulphonic acid.
This substance has always been used as a developer in photography and is considered one of the best; it has recently been introduced into industry as an additional product in baths for dyeing skins; it is used for tinting the hair and beard, and in chemistry for gas analysis (absorption of oxygen).

Trioxybenzene acts upon the circulation, lowers the temperature and causes clonic convulsions, tetanic movements, muscular paralysis, etc. The poisonous dose for a man by way of the digestive tract is about 10 grammes (Kohn Abrest). It is a blood poison transforming the haemoglobin of the red corpuscles into methaemoglobin.
Its poisonous action is attributed to an increase in the number of the hydroxyl groups, for trihydroxybenzene is certainly more poisonous than phenol which is a monohydroxybenzene.

Lehmann is not aware of any case of industrial poisoning caused by this product. Nevertheless, its action, both local and general, is emphasised by the dermatitis seen, for example, among photographers. It is interesting to learn that this dermatitis sometimes occurs suddenly with persons who have worked for a long time without injurious effects. P. White thinks that in those cases small daily doses create an anaphylactic condition, during which a very small quantity at a given moment may cause in a few hours (12 to 24) a very marked reaction. In slight cases there are noticed irritation and tingling about the nails and in the interdigital spaces with cracking of the skin.

According to Hamilton some cases of poisoning by trihydroxybenzene have occurred in Germany, while on the other hand a case of poisoning has never been seen in an American factory making gallicyanine.

Weickel reported to the Medical Society of Leipzig (1922) the result of experimental investigations, according to which pyrogallol diminishes the number of red corpuscles without affecting the bone marrow, increases the number of blood platelets, and diminishes the viscosity of the blood.

As regards legislation (compensation for diseases) see the articles "Diseases of the Skin" and "Photographers".

BIBLIOGRAPHY

Tripe and Gut Works


Certain parts of slaughtered animals (stomach, head and feet, etc.), sometimes designated by the term "edible offal", are used in the preparation of tripe and other meats, which takes place in slaughter-houses or in wholesale butcher meat establishments. The operations involved in this work comprise, according to the different parts of the animal treated, insufflation, washing, boiling, scalding and scraping. The waste fat after melting is utilised for the manufacture of tallow. Modern technical methods have now substituted treatment by hypochlorite of soda, or Labarraque's solution, for the nauseating operation of putrid fermentation. Formerly, the workers resort to with a view to separating the various layers of the intestinal wall. By this method the intestines lose their odour, the membrane is easily separated, and insufflation takes place without inconvenience for the workers.

Insufflation was formerly done by the mouth by means of a reed introduced into the base of the intestine. At present insufflation apparatus is used. The guts, subsequent to insufflation, are sent to be dried, and after drying are pricked, de-flated and treated with sulphur in order to whiten them and rid them of their odour.

The guts of large animals are used chiefly in the manufacture of products sold by pork butchers, etc. (making of sausages and other varieties of similarly prepared meat); those of smaller animals are used in the preparation of various kinds of gut for musical instruments, the clock-making industry, hat-making industry, etc.

The preparation of catgut forms a part of the tripe and gut industry, which provides a series of waste products for pork butchers, farmers, etc.

Surgical gut and harmonic strings may be manufactured from preserved, dried or salted guts coming from distant countries, or with guts macerated in water and fermented or again with fresh guts taken directly from the dead animal. Authorities on the subject are agreed that catgut should not be prepared from fresh gut. Sheep gut after emptying and washing in the slaughter-house is sent to the gut works, where it is subjected to scraping and steeping in aspecific solutions. Finally, it is split in order to provide a flat strip which is submitted to treatment with hydrogen peroxide. By plaiting several of these strips a cord is obtained which is subsequently dried, polished and sent to the chemical works for sterilisation by steam or alcoholic fumes.

Scraping and plaiting should be effected in separated, well-ventilated work-rooms in the gut works. Strict cleanliness of the workrooms and also of the worker should be required with a view to avoiding contamination with any matter embedded in the walls of the gut. Goldbeaters' skin is made from the caecum of the ox which has been dried, dipped in a dilute solution of potassium, scraped with a knife, lined with a similar membrane, and coated with a dressing of fish glue and white of egg.

Sources of Risk

The work engaged in in tripe and gut works is one of the most filthy tasks imaginable. Apart from the nauseating odours, there must likewise be taken into account the humidity present in the workrooms as a result of the presence of large quantities of liquid used. There is liability to infection due to contact with water and matter containing pathogenic microbes. Cases of anthrax have been known to occur due to manipulation or transport of gut from anthrax infected cattle.

In a catgut factory, Saltikowsky (1929) found workers exposed to continuous inhalation of pumice-stone and chalk dust during polishing of the cords and strings.

He has also drawn attention to the action of products used in the preparation of gut and cord: hypochlorites, soda and potassium lyes, sulphurous dioxide, iodine, peroxide of hydrogen.

Pathology

Medical authors who during the course of the nineteenth century directed their attention to the health of workers in tripe and gut works, at a moment when hygienic conditions in the industry were greatly inferior to what they are at present, reported with a certain amount of surprise that work in these establishments, on the contrary to what might be expected, did not appear to predispose those engaged in the work to disease (Guersant, Parent-Duchatelet, Patissier). However, Chevalier, Guérard and Layet report that the workers in question, from the commencement of their entry into the trade, suffer from fever, digestive troubles, pallor, etc., symptoms which nevertheless disappear fairly rapidly.

Labarraque has reported injuries due to insufflation with the mouth. It was found impossible to continue this operation for more than three days at a time. It gave rise after a time to chronic irritation of the pharynx, with ulceration at the commissure of the
lips, lesions which Vernois likewise
met with, and which he attributed to
the action of the septic liquid on the
skin during insufflation of the guts.

Contact with water and lyes caused
wearing of the epidermis of the hands
which had a raised appearance in
certain places with cracks between
the fingers. There was likewise noted
a certain anesthesia of the hands and
forearms similar to that reported by
Romberg amongst washermen.

Cutaneous lesions amongst workers
making catgut have been more recently
reported by Saltikowsky. A particular
alteration of the hands due to work
in gut works has been described by
Vernois. The internal surface of the
left hand, which usually holds the
bunch of guts was of rose-red colour,
very smooth and presented cracks and
worn epidemis, which had a very thin
appearance, being more injected after
working hours than during work.

The right hand with a callosity in the
centre was equally rosy in colour,
though irritations and cracks between
the fingers were of less frequent occur-
rence; the nails were worn at the
edges and the skin of the hand had a
particular smell.

These alterations were explained by
the fact that intestines were handled
with the left hand more frequently
and more completely than with the
right; by the action on the right hand
of the knife used for scraping; by that
of the skin of old fermented gut; and
by the action of septic liquids.

Saltikowsky noted also deformation
of the fingers amongst workers en-
gaged in making catgut as well as
vasomotor derangements affecting the
feet and hands as a result of pro-
longed contact with water, rheumatism
and diseases of the heart, sore throats,
pharyngitis, and tonsillitis.

Sulphurous dioxide caused irritation
of the eyes and respiratory passages
amongst workers engaged in the sul-
phur process.

HYGIENE

Tripe and gut works should be con-
structed at as great a distance as
possible from inhabited areas, and in
order to complete this isolation it has
been suggested that wherever possible
trees and shrubs of rapid growth
should be planted round these estab-
lishments to a depth of 17 or 20 metres.
Where the odour given off is not
unduly strong and not such as to
constitute a nuisance for the neigh-
bourhood, it suffices that the establish-
ment should be provided with lantern
or raised skylight windows with ven-
etian blinds, or with small chimneys
raised above the roof.

Such establishments should be
constructed of hard, incombustible
material resisting putrefaction. The
courtyards should be paved and the
paving stones joined with cement
mortar.

The flooring of the workrooms
should be impermeable (cemented, tiled,
or covered with bitumen), with a con-
venient slope facilitating the running
off of the waste water. There should
be drains in the flooring provided
with grids to prevent the withdrawal
of solid waste, and these grids should
be connected up with airtight and
watertight piping underground en-
abling the liquids to be drawn off.

The walls should be covered with a
smooth paint, resistant to washing
down with large quantities of water
(cement up to a certain height, plaster
above that as well as on the ceiling).
The woodwork should be painted with
washable oilpaint. The joins between
the walls and the flooring and be-
 tween the flooring and the tiled or
paved spaces round the fixed appara-
tus, machine bases, etc., should have
rounded angles. Hollow spaces and
mouldings should be avoided as far as
possible.

Furnaces built of masonry and hot-
water vats should be provided with
large exhaust hoods for capturing and
removing fumes and steam. The sul-
phur chamber should be made of in-
combustible material and provided
with large ventilating chimneys with
dampers which can be manipulated
from the outside. In a general man-
ner all apparatus, vats, etc., should be
provided with hoods connected up
with suitable piping for withdrawing
the fumes to a hearth or a chimney.
The latter should be of an adequate
height. Certain legislative require-
ments even demand that the top of
this chimney should be equal in height
to the chimneys of the houses within
a radius of 100 metres and that its
direction should be rationally deter-
mined, in accordance with the prevail-
ing winds, with a view to avoiding
nuisance for those living in the neigh-
bourhood.

Good ventilation of the workrooms
should be ensured. Stores of raw
material should be provided with ven-
tilation piping. Tables on which the
materials are sorted should have an
impermeable surface. The premises
should be maintained in a good state
of repair and cleaned frequently by
means of washing down with abundant
water. Nauseating liquids should be withdrawn by means of pneumatic apparatus and directed towards sewers. Where no sewers exist, waste waters should be withdrawn through metallic grids or perforated sheet iron, calculated to retain the particles in suspension. The waste water should be collected in decantation tanks and distributed on cultivated ground or else treated by chemical processes. Solid refuse should wherever possible be collected daily, deodorised, and when necessary disinfected.

Fresh gut from slaughter-houses, where it has been previously washed and emptied, should be worked up immediately in hermetically sealed receptacles.

Gut should be sprinkled with a suitable antiseptic immediately it is received, and should be kept in impermeable receptacles (not wooden) which are hermetically sealed. Material likely to liberate odours should be treated as far as possible in closed apparatus.

The manufacture of manure and the melting of tallow in the same work-room as that used for removal of fat should be prohibited; the fermentation process should likewise be prohibited and replaced by the Labarraque process.

Washing vats should be of impermeable material readily cleansed and provided with separate pipes for introduction of clean water and for withdrawal of waste water.

Insufflation by blowpipe should be compulsory, and workers should be prohibited from entering the sulphur chambers prior to complete ventilation and airing of these.

Spoilt products and refuse should be collected in closed, airtight receptacles and deodorised (formol, chloride of lime). These receptacles should be emptied daily.

Measures for individual cleanliness: working clothes, aprons and waterproof boots should be provided for those workers in contact with the liquids. There should be adequate provision of sanitary arrangements (washing accommodation with provision of hot water, soap, towels, etc.), adequate cloakroom accommodation, etc.

**Legislation**

In Belgium, young persons under sixteen are excluded from slaughtering processes in which intestines and offal are prepared or boiled or where heads and feet of animals are handled; from the manufacture of animal gut necessitating disintegration of intestines with a view to separating the gut from the mucous membrane by putrefaction methods. In Spain, boys under sixteen and women under twenty-one are excluded from cleaning and removal of membrane from bladders and guts and are likewise excluded from workrooms in which processes of cleaning and insufflation are carried out. In France, young persons under eighteen are excluded from processes of insufflation as well as from workrooms in which bladders are inflated and dried; the same measures are in force in Martinique and Morocco, where, however, the age limit of the young persons is reduced to sixteen years.

In certain countries (Belgium, France, Italy, etc.), tripe and gut works come within the category of enterprises scheduled as dangerous, unhealthy and offensive, and are on this account subjected to a certain number of special measures enumerated in the preceding paragraph.

In Great Britain, Order No. 1437 of July 1920 concerning the welfare of workers occupied in tripe and gut works provides for the provision of working clothes, cloakrooms, canteens, lavatories, first-aid boxes, etc., to be placed at the disposal of the workers.

In the U.S.S.R., Compulsory Order No. 333/796 of 13 September 1923 on the installation and maintenance of tripe and gut works includes most of the hygiene measures enumerated above.

**Bibliography**


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**Tuberculosis**


This article is divided into two parts, as follows: I, Industrialism and the Incidence of Phthisis, and II, Silicosis.

I. — **Industrialism and the Incidence of Phthisis**

The three factors of fundamental import in determining the incidence and evolution of tuberculosis infection are the individual, environment and occupation. It is the third of these factors which it is proposed in analysis in this article, for occupation is often an element of first importance in the aetiology of infection and the degree of development of industrialism in a district or in a country and
The reaction of the human body to tuberculous infection varies with the condition of the body at the time infection occurs. This fact can be demonstrated from study of the disease clinically, or of mortality statistics referring to different conditions of environment or to different occupational groups of a community. In the present stage of the world's history, civilisation and the keeping of vital statistics connote industrialism. Though records are lacking upon which to found knowledge as to the reaction of non-industrialised communities, some knowledge, based on clinical experience, exists as to the reaction of primitive or isolated communities when the infection of tuberculosis is first introduced: the disease, which runs a rapid course, is found far more widely disseminated throughout the body than is the case in industrialised communities.

Records for Sweden at the end of the eighteenth and beginning of the nineteenth century provide valuable information with regard to a civilised community before it adopted industrialism (see Table 1). Leaving on one side the obvious criticism that the data tabulated may have included cases of chronic bronchitis and not merely referred to pulmonary tuberculosis, these records exhibit for both males and females a death rate somewhat similar in age distribution to a "normal" death rate, i.e. it is high in infancy, falls to a minimum in childhood, and thereafter rises, at first slowly and then more rapidly, as life advances. The picture is quite different from that presented by the same country in 1911, after the adoption of industrialism during the last quarter of the nineteenth century. A high mortality in infancy and a fall to a minimum in childhood are still present, but a new thing is found, a rise for both sexes in young adult life which declines towards middle age and shows a tendency to rise again before old age is reached; this late rise is less pronounced for females than for males.

When evidence is sought as to the course of events in the years intervening between 1830 and 1911 — records for which are lacking in the case of Sweden — Ireland from the middle of last century is found to provide suggestive material. Ireland has never been so pronouncedly industrial as England, but it certainly felt the industrial influence earlier than Sweden. The highest death-rate from phthisis in Ireland for both sexes from 1851 to 1860 was experienced, just as in early Swedish records, at the end of life, when the ages did not rise above 65.

### Table 1. — Death Rates per 1,000 Living from Phthisis in Certain Countries

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<td>3.70</td>
<td>2.91</td>
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<td>0.81</td>
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<td>4.03</td>
<td>4.02</td>
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Explanation of the figures in heavy type and in italics will be found in the text.
before finally rising again to the terminal age period. By 1871-1880 the death rate for males was highest at ages 25-34, after which age it fell away to rise again at ages 55-64; the curve now resembles in shape that for Sweden in 1911. By 1901-1910 the age distribution of the phthisis death rate in Ireland had undergone further alteration; for both sexes the maximum incidence was now at ages 25-34, after which it fell away steadily with advancing years; there is now no sign of a rise in late life. The curve for the death rates after the age of 15 is now decidedly aberrant; it rises during early adult life and thereafter falls with advancing life.

This type of curve is to be found in England and Wales in 1851-1860 when the full effect of the altered conditions of life brought about by the industrial revolution was being felt (see fig. 157). The same type of curve existed in Czechoslovakia in 1910 when that country had reached a stage of industrialism similar to that which existed in England and Wales between 1851 and 1860.

Other countries, on the other hand, upon which industrialism had much less effect, such as Prussia up to 1914, and Victoria, Australia, have maintained a curve for phthisis death rates throughout life which has agreed more or less closely with the shape of a normal curve of mortality from all causes.

When the course of events is followed for countries where the aberrant type of curve has appeared, a tendency is found, as the conditions of living improve, for the type of curve to alter steadily in the direction of conforming more closely to a normal mortality curve: thus the apex of the curve for males in England and Wales had moved from ages 20-24 in 1851-1860 to ages 50-54 by 1911, while in New York City the apex for males (which in 1868 was at the end of life) moved from ages 45-49 in 1910 to ages 55-64 in 1921.

Further evidence from mortality records of other countries might be quoted to establish the influence exerted upon the prevalence of phthisis by the disturbances which the development of industrialism has caused. The effect of industrialism appears to act by modifying the resisting power of the community at different ages to the infection of tuberculosis.

When the infection is introduced for the first time into any community, it causes a generalised disease of high fatality; if the community is not wiped out by the epidemic, it gradually acquires a degree of resistance to the disease which now becomes statistically endemic and clinically more chronic. When the disease has become truly endemic, the mortality it causes at different periods of life resembles that due to other forms of mortality, such as enteric diseases and bronchitis, i.e. it claims its victims among the newly-born possessing an atavistic lack of resisting power, and among those, particularly the old, whose initial power of resistance has been broken down by the wear and tear of life.

Should, however, the resisting power of a community among which the disease is endemic—such communities as all civilised nations in the Middle Ages—be modified by such changes in environment as followed upon the industrial revolution, then the type of the disease changes statistically and clinically; statistically it attacks at that period of life—adolescence—when the changes are most felt; clinically it becomes more active and less
The disease at this stage in its manifestations now stands midway between an acute infectious epidemic and a chronic endemic disease. Whether the maleficent process could be pushed further so that the disease reverts to an acute endemic type, there is no sure evidence to show. Fortunately the further development of industrialism has brought better environmental influences into existence, and the tendency has been for the disease to resume its more chronic endemic type. As the prevalence of the disease dies down, it finds its last stronghold in late life when the resisting power of the body is growing weaker with age, and among males whose occupational activities subject them to considerable strain and stress.

The food supply has become more plentiful, has fallen rapidly and the age most concerned in the fall has been early adult life, even though the maximum incidence shows a tendency to remain at that age.

When consideration is given to the changes produced by the industrial revolution, at once the question of food supply is recognised to have been of the utmost importance. In England the population, which up to 1700 had been almost stationary for at least 300 years, multiplied rapidly and soon the countryside could not provide locally the needed food. Road transport was thoroughly bad. Canals at first were practically non-existent and at best provided inadequate means. Railways were only started about 1840. Increased earnings drew the food supplies into the industrial centres and soon the farm labourer could only afford a little meat once a week and milk not at all. Importation of food commenced, but so long as ships depended, as they did for the most part up to 1870, upon wind power, only material which did not rapidly deteriorate, such as grain and cotton, could be carried; cold storage and quick voyages were not yet.

Disturbance of food supply has probably been the great factor exerted by industrialism upon the incidence of phthisis, and its influence has been most felt in England the population, which up to 1700 had been almost stationary for at least 300 years, multiplied rapidly and soon the countryside could not provide locally the needed food. Road transport was thoroughly bad. Canals at first were practically non-existent and at best provided inadequate means. Railways were only started about 1840. Increased earnings drew the food supplies into the industrial centres and soon the farm labourer could only afford a little meat once a week and milk not at all. Importation of food commenced, but so long as ships depended, as they did for the most part up to 1870, upon wind power, only material which did not rapidly deteriorate, such as grain and cotton, could be carried; cold storage and quick voyages were not yet.

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in young adult life. The adequacy of food supply must, however, always be measured by the need for energy output; a dietary adequate for the sedentary life of a clerk is quite inadequate for a navvy or a coalminer. Here modern industrial methods, by introducing labour-saving devices, help to lighten the strain placed upon the food supply of the community.

Alcoholism

Another important social factor has been an increase in the alcohol habit as compared with the Middle Ages; this increase was synchronous with the birth of industrialism, and probably was closely related to it. The conditions of labour in those early years, with long hours spent in close atmospheres at uncongenial work, lowly paid, tended to produce that irritable tiredness associated with thirst for which an alcoholic beverage seems a heaven-sent panacea. The habit so implanted in the community is only now slowly being lifted as conditions of work and the social status of the workers are being ameliorated. Statistics exhibit occupational groups, such as innkeepers and casual labourers, brewers and barmen with high mortality from alcoholic diseases, as well as high mortalities from other causes of death, amongst which phthisis stands high. (See the article "Alcoholism ".)

OCCUPATIONAL INFLUENCES

The existence of a close association between occupation, particularly of industrial type, and phthisis mortality is seen when the mortality for males is compared with that for females in selected (non-industrial) rural and (industrial) urban counties in England and Wales. These are contrasted for different age periods in figs. 159 and 159A. The female death rate from phthisis in early life in both town and country exceeds the male, giving some indication that, given similar conditions, females are as liable as males to phthisis; this fact is further exemplified by countries such as the Netherlands and Japan in recent years and England and Wales in 1851-1860, where the female phthisis rate for all ages is found to exceed the male. From ages 20-24 onwards occupation is particularly the distinguishing characteristic of the male, even though some females are occupied, particularly in industrial areas. From this age period the male death rate exceeds the female; the excess is most pronounced in the industrial urban counties and at middle age.
The female death rate in the industrial counties exhibits some occupational influence in that the age of maximum incidence is later than in the rural counties. Up to the age of 30 the death rates for both sexes is higher in the rural than in the urban counties, due possibly to the greater command of food in the urban areas brought about by greater wealth.

The main point brought out is that the adult male seems quite definitely in Great Britain to be subjected, so far as phthisis is concerned, to more adverse influences than the female, and these influences are definitely associated with industrial occupation. Hence further investigation of these influences may with most advantage be pursued by examining mortality statistics for males, distributed according to occupation.

**General Influences**

Two general influences are exerted upon the prevalence of phthisis by occupations; these depend upon (a) the infectious character of the disease, i.e. its communicability from person to person, and (b) the capacity of the human organism for having its resistance to the infection modified by occupational environment.

An infectious disease is obviously more prevalent the greater the opportunities for transmitting the infection. If the possibility be accepted that at least a proportion of cases of phthisis in adults is due to adult infection, then the undue prevalence of the disease in certain industries is open to explanation; examples of the industries for which this explanation is required are, in England and Wales, printing, tailoring, and shoemaking. Each has, during the period covered by the statistics quoted in table II, been carried on indoors in factories where the aggregation of workers has been such as to facilitate the transmission of infection. Clerical occupations, as exemplified by law clerks and commercial clerks, present somewhat similar opportunities for infection, and here also phthisis is found to be unduly prevalent.

Examination of the mortality, due to other causes of death, experienced in these occupations does not support the idea that the resistance to disease in general is decreased by these occupations, since apart from phthisis no other disease provides a mortality distinctly above the standard. While the phthisis death rate, in each decennial period, quoted in table II, stands out for each of these occupations as particularly high, it fell greatly between 1890-1910; but this fall is synchronous with a somewhat similar fall in the phthisis death rate for all males. The evidence is compatible with the hypothesis that, while the prevalence of phthisis in these occupations is a function of opportunity for infection, it is also profoundly influenced by the resisting power to disease in general of those exposed to infection.

In contradistinction to the Industries just mentioned, come the textile industries — cotton, woollen and hosiery. Here the physical exertion called for is comparable with that of printing, tailoring and shoemaking, and the industries are similarly carried on indoors in factories; but the aggregation of operatives is less pronounced owing to the size of the looms, spinning frames, knitting and other machinery. The machines separate individual from individual, and the prevalence of phthisis in these industries is not unduly high, even though in the case of certain operatives, e.g. the strippers and grinders of cotton carding machines, the lungs are adversely affected by inhaling dust, as is shown by the high mortality from respiratory diseases other than phthisis.

Attention has already been directed to the influence exerted upon phthisis mortality by food; the influence of this factor is further stressed by noting the high incidence of phthisis in occupations of low social status of which unskilled labour provides examples in dock labourers and costermongers. Low social status, however, is associated with other things besides, and among these stand a tendency to indulge to excess in alcohol; indulgence in alcohol is recognised to lower resistance to disease in general. Hence the high incidence of phthisis in the industries quoted cannot be simply attributed to the poor food supply necessitated by a low income. The influence exerted by occupation in this instance is a social rather than a purely occupational one.

Attention may here be directed to the way in which a high mortality from phthisis is found associated with different combinations of mortality rates from other causes which vary with the prevalent factor in the phthisis causation. Thus, when opportunity for infection is the prevalent factor, as in the case of printers, tailors and shoemakers, the mortality from phthisis is the only one which is unduly high; when the prevalent factor is alcoholism, which lowers the resistance...
TABLE II. — COMPARATIVE MORTALITY FROM CERTAIN CAUSES AMONG MALES IN CERTAIN OCCUPATIONS, ENGLAND AND WALES 1.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Period</th>
<th>Phthisis</th>
<th>Pneumonia</th>
<th>Bronchitis</th>
<th>Bright's disease</th>
<th>Cirrhosis of liver and alcoholism</th>
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<td>Hostery operatives</td>
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<td>225</td>
<td>72</td>
<td>39</td>
<td>14</td>
<td>25</td>
<td>921</td>
</tr>
<tr>
<td></td>
<td>1910-12</td>
<td>176</td>
<td>34</td>
<td>35</td>
<td>26</td>
<td>7</td>
<td>736</td>
</tr>
<tr>
<td>Dock labourers</td>
<td>1890-92</td>
<td>377</td>
<td>254</td>
<td>329</td>
<td>47</td>
<td>90</td>
<td>2,114</td>
</tr>
<tr>
<td></td>
<td>1900-02</td>
<td>308</td>
<td>187</td>
<td>137</td>
<td>41</td>
<td>72</td>
<td>1,481</td>
</tr>
<tr>
<td></td>
<td>1910-12</td>
<td>232</td>
<td>142</td>
<td>64</td>
<td>40</td>
<td>30</td>
<td>1,127</td>
</tr>
<tr>
<td>Costermongers</td>
<td>1890-92</td>
<td>514</td>
<td>197</td>
<td>221</td>
<td>55</td>
<td>75</td>
<td>1,911</td>
</tr>
<tr>
<td></td>
<td>1900-02</td>
<td>554</td>
<td>177</td>
<td>185</td>
<td>55</td>
<td>99</td>
<td>2,007</td>
</tr>
<tr>
<td></td>
<td>1910-12</td>
<td>421</td>
<td>141</td>
<td>104</td>
<td>62</td>
<td>36</td>
<td>1,667</td>
</tr>
<tr>
<td>Tin miners</td>
<td>1890-92</td>
<td>588</td>
<td>123</td>
<td>186</td>
<td>34</td>
<td>37</td>
<td>1,628</td>
</tr>
<tr>
<td></td>
<td>1900-02</td>
<td>616</td>
<td>81</td>
<td>206</td>
<td>50</td>
<td>12</td>
<td>2,121</td>
</tr>
<tr>
<td></td>
<td>1910-12</td>
<td>684</td>
<td>95</td>
<td>76</td>
<td>54</td>
<td>12</td>
<td>1,579</td>
</tr>
<tr>
<td>Lead miners</td>
<td>1890-92</td>
<td>440</td>
<td>147</td>
<td>142</td>
<td>38</td>
<td>45</td>
<td>1,514</td>
</tr>
<tr>
<td></td>
<td>1900-02</td>
<td>336</td>
<td>84</td>
<td>53</td>
<td>10</td>
<td>33</td>
<td>1,206</td>
</tr>
<tr>
<td></td>
<td>1910-12</td>
<td>335</td>
<td>40</td>
<td>50</td>
<td>47</td>
<td>18</td>
<td>1,185</td>
</tr>
<tr>
<td>Sandstone masons</td>
<td>1910-12</td>
<td>415</td>
<td>120</td>
<td>116</td>
<td>68</td>
<td>18</td>
<td>1,427</td>
</tr>
<tr>
<td>Limestone masons</td>
<td>1910-12</td>
<td>129</td>
<td>54</td>
<td>39</td>
<td>33</td>
<td>13</td>
<td>753</td>
</tr>
<tr>
<td>All iron miners</td>
<td>1890-92</td>
<td>104</td>
<td>100</td>
<td>97</td>
<td>17</td>
<td>71</td>
<td>833</td>
</tr>
<tr>
<td></td>
<td>1900-02</td>
<td>136</td>
<td>69</td>
<td>42</td>
<td>8</td>
<td>25</td>
<td>744</td>
</tr>
<tr>
<td></td>
<td>1910-12</td>
<td>73</td>
<td>76</td>
<td>37</td>
<td>21</td>
<td>5</td>
<td>672</td>
</tr>
<tr>
<td>Iron ore miners</td>
<td>1910-12</td>
<td>123</td>
<td>114</td>
<td>80</td>
<td>25</td>
<td>6</td>
<td>982</td>
</tr>
<tr>
<td>Boiler makers</td>
<td>1890-92</td>
<td>155</td>
<td>165</td>
<td>133</td>
<td>37</td>
<td>39</td>
<td>1,162</td>
</tr>
<tr>
<td></td>
<td>1900-02</td>
<td>150</td>
<td>102</td>
<td>78</td>
<td>20</td>
<td>34</td>
<td>1,032</td>
</tr>
<tr>
<td></td>
<td>1910-12</td>
<td>111</td>
<td>65</td>
<td>46</td>
<td>37</td>
<td>12</td>
<td>754</td>
</tr>
<tr>
<td>Slate-quarriers</td>
<td>1910-12</td>
<td>226</td>
<td>87</td>
<td>38</td>
<td>36</td>
<td>36</td>
<td>890</td>
</tr>
</tbody>
</table>

1 Figures printed in heavy type exceed the standard set by all males for the same decennial period.
to disease generally, mortalities from all other causes are high; but when the prevalent factor is dust inhalation, as exemplified by silica dust, vide infra, a high mortality from phthisis is found associated with high mortalities from bronchitis, pneumonia and Bright's disease, but not from any other cause of death. This method of detecting by differential mortality the factor influencing the prevalence of phthisis in any occupational group is one of great statistical value.

II. — Silicosis

The general influences, so far as they have been traced, exerted directly or indirectly by occupation upon the prevalence of phthisis have been stated. There remain for consideration particular influences, by which is meant those specific influences, peculiar to definite industrial processes, which render workers more than normally liable to succumb to pulmonary tuberculosis.

The typical example of such an influence is the inhalation of silica dust. Knowledge as to this form of phthisis is based nearly entirely upon study of statistical, clinical and pathological manifestations in industries where risk of inhaling silica dust exists. It exists in many industries; in most gold mines, tin mines, and lead mines, and generally in mining and quarrying in flint, chert, granite, millstone, quartz, or buhrstone; in dressing and grinding of wheels of sandstone, millstone, or buhrstone; grinding articles on wheels of sandstone, millstone or buhrstone; in dressing and carving granite, millstone, millstone grit, or buhrstone; in flint knapping; in crushing or brocking silica, sometimes called secondary white mica, belonging to the mica group of minerals containing SiO₂ 45.56 per cent., Al₂O₃ (37.46), Fe₂O₃ (0.80), MgO (1.16), K₂O (6.35), Na₂O (0.66), traces of CaO.) In every silicotic-lung section examined, fibres of sericite were particularly numerous, although many small grains of quartz were also present. Following a survey of the chemical analyses of the ash and the mineral residues of silicotic lungs and a comparison of the silica rocks causing silicosis with those which did not, Jones discussed rocks low in their content of free silica which nevertheless caused silicosis. More certain mills crushed pure quartz 99 per cent. free silica without the incidence of a single case of silicosis. The question whether sericite is a primary factor of silicosis still remains open to discussion.

Statistical Evidence

The inhalation of dust has long been recognised to be injurious. Many early writers noted the fact, from Pliny the elder and Georgius Agricola to Diemerbroek and Ramazzini. Metallic-ferous miners, stonecutters, potters, hemp and flax workers are mentioned as affected; but in times when phthisis was not clearly distinguished from other respiratory diseases, the precise disease alluded to cannot always be recognised. Certain events in the nineteenth century came to help; first, phthisis was more definitely recognised as a clinical entity, mortality statistics were collected; thirdly, the tubercle bacillus was discovered. Medical opinion continued up to the commencement of the twentieth century to hold as a broad truth that the inhalation of any kind of dust predisposed to diseases of the lungs which pulmonary tuberculosis was the chief. The intensive investigations prosecuted by E. L. Collis into the prevalence of phthisis in certain occupations and into the amount and kind of dust present, indicated that, at any rate so far as phthisis is concerned, the kind of dust was of primary importance, and that workers, such as makers of cement and masons dressing limestone, could be exposed to extensive amounts for many years without exhibiting any tendency to succumb unduly to phthisis. On the other hand, wherever phthisis attributed to dust was found in excess, one element, silica, was always found to be present. The fact is well brought out in table III.

Here in all industries involving exposure to dust containing appreciable amounts of silica phthisis is found to be unduly prevalent; but the silica must be present as SiO₂; dusts of silicates do not exhibit this phenomenon. The order stated in the table is arranged according to mortality and exhibits a close relation to the amounts of silica present in the different dusts; exceptions to this rule are caused by the exposure being more intense in some processes than in others, for example, the pneumatic tool of the granite cutter raises more dust than the chisel and mallet of the stone-mason.

Further examination of mortality records disclosed that mortality from phthisis as exhibited by groups of persons exposed to the inhalation of silica dust displayed certain definite statistical characteristics. One of these has already been mentioned, namely, that the excessive mortality from phthisis is associated with
TABLE III. — MORTALITY FROM PULMONARY TUBERCULOSIS IN VARIOUS DUSTY TRADES

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Composition of dust</th>
<th>Annual death-rate per 1,000 living</th>
<th>Deaths from phthisis expressed as percentage of deaths from all causes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Free silica</td>
<td>Other constituents</td>
<td></td>
</tr>
<tr>
<td>Flint knappers (Brandon)</td>
<td>100 per cent.</td>
<td>—</td>
<td>11.3</td>
</tr>
<tr>
<td>Gannister miners (Stockbridge)</td>
<td>95 per cent.</td>
<td>—</td>
<td>17.6</td>
</tr>
<tr>
<td>Sandstone cutters (Germany)</td>
<td>Up to 95 per cent.</td>
<td>—</td>
<td>0.0</td>
</tr>
<tr>
<td>Tin mining</td>
<td>Up to 75 per cent.</td>
<td>Tinstone, feldspars and micas</td>
<td>16.7</td>
</tr>
<tr>
<td>Sandstone masons (Grinshill)</td>
<td>Up to 96 per cent.</td>
<td>Some oxide of iron</td>
<td>15.0</td>
</tr>
<tr>
<td>Grinders (Sheffield)</td>
<td>50 to 100 per cent.</td>
<td>Feldspars and micas</td>
<td>(1905-09)</td>
</tr>
<tr>
<td>Granite cutters (Maine and New Hampshire, U.S.A.)</td>
<td>30 per cent.</td>
<td>—</td>
<td>(1915-18)</td>
</tr>
<tr>
<td>Gold mining (Transvaal)</td>
<td>Gold-bearing quartz, i.e. silica</td>
<td>Other minerals</td>
<td>3.3</td>
</tr>
<tr>
<td>Gold mining (Bendigo)</td>
<td>Do, do, 30 per cent.</td>
<td>—</td>
<td>3.2</td>
</tr>
<tr>
<td>Granville cutters (Aberdeen)</td>
<td>80 to 90 per cent.</td>
<td>Lead ore, Lime.</td>
<td>4.5</td>
</tr>
<tr>
<td>Sandstone masons, getters and dressers</td>
<td>Quartz and chert, i.e. silica</td>
<td>stone sometimes takes the place of quartz in mother rock (Alumina) China clay</td>
<td>3.1</td>
</tr>
<tr>
<td>Lead mining</td>
<td>Flint, i.e. silica in certain processes only</td>
<td>—</td>
<td>1.7</td>
</tr>
<tr>
<td>Potters</td>
<td>—</td>
<td>Alumina and silicates</td>
<td>—</td>
</tr>
<tr>
<td>Occupied and retired males (15 years and over)</td>
<td>—</td>
<td>Calcium carbonate and clay</td>
<td>3.1</td>
</tr>
<tr>
<td>Brickmakers</td>
<td>—</td>
<td>Calcium sulphate, silicates, etc.</td>
<td>1.3</td>
</tr>
<tr>
<td>Lime and brick burners (Switzerland)</td>
<td>Felspar and micas</td>
<td>Chiefly aluminium silicate</td>
<td>1.8</td>
</tr>
<tr>
<td>Gypsum, cement, asphalt workers (Switzerland)</td>
<td>A small amount</td>
<td>Husk of cotton and debris</td>
<td>1.7</td>
</tr>
<tr>
<td>Slate quarrying</td>
<td>About 1 per cent.</td>
<td>Calcium carbonate</td>
<td>1.7</td>
</tr>
<tr>
<td>Stripping and grinding cotton carding machines</td>
<td>About 1 per cent.</td>
<td>Ironstone and limestone</td>
<td>1.5</td>
</tr>
<tr>
<td>Limestone masons (Derbyshire)</td>
<td>About 1 per cent.</td>
<td>Calcite carbonate</td>
<td>1.6</td>
</tr>
<tr>
<td>Limestone cutters (Sue, New Hampshire)</td>
<td>About 1 per cent.</td>
<td>Various silicates</td>
<td>1.3</td>
</tr>
<tr>
<td>Ironstone mining</td>
<td>—</td>
<td>Coal measures</td>
<td>1.0</td>
</tr>
<tr>
<td>Millers</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Manufacture of plaster and cement</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Coal-mining</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

1 Where not otherwise stated, the records are taken from the Supplement to the Seventy-fifth Annual Report of the Registrar-General for England and Wales, Part IV.

Excessive mortalities from bronchitis, pneumonia and Bright’s disease; this combination, in the absence of excessive mortalities from other causes of death, is quite distinctive. Silica dust shares with various other dusts, such as vegetable husks, emery, and basic slag, a capacity for overtaxing the ciliary mu cosa of the air passages and rendering them more prone to succumb to bronchitis and pneumonia; but these latter dusts are not associated with excessive mortalities from phthisis and Bright’s disease. The reasons why the mortalities from the last-named diseases are excessive will be discussed when the pathological action of silica is described.

The combination of high mortalities from phthisis, bronchitis, pneumonia and Bright’s disease is also found in groups where alcoholism prevails; but in those groups the mortalities from other causes of death, particularly from alcoholism and cirrhosis of the liver, are also in excess.

The second statistical characteristic is that the age of maximum incidence of phthisis in a “silica group” is, and always has been, late in life. This point is brought out in the figures given in Table IV. This characteristic is one of some importance and will be used as a means of statistical differential diagnosis later. Its exact meaning is not clear; it would agree with the idea that silica, by gradually damaging the lungs, lowers their general resistance to disease, and so prepares the way for phthisis which in late life is an accompaniment of wear and tear, attacking those whose lungs have
### TABLE IV. — MORTALITY FROM PHthisIS AMONG MALES PER 1,000 LIVING IN CERTAIN OCCUPATIONS IN ENGLAND AND WALES

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Period</th>
<th>Age period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1890-92</td>
<td>1900-02</td>
</tr>
<tr>
<td></td>
<td>15-</td>
<td>20-</td>
</tr>
<tr>
<td>All males</td>
<td>1.11</td>
<td>2.15</td>
</tr>
<tr>
<td></td>
<td>0.82</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>0.74</td>
<td>1.38</td>
</tr>
<tr>
<td>Printers</td>
<td>1.42</td>
<td>4.21</td>
</tr>
<tr>
<td></td>
<td>1.03</td>
<td>3.45</td>
</tr>
<tr>
<td></td>
<td>0.78</td>
<td>2.60</td>
</tr>
<tr>
<td>Shoemakers</td>
<td>1.08</td>
<td>2.73</td>
</tr>
<tr>
<td></td>
<td>0.03</td>
<td>2.35</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>2.20</td>
</tr>
<tr>
<td>Tailors</td>
<td>0.81</td>
<td>2.73</td>
</tr>
<tr>
<td></td>
<td>0.54</td>
<td>1.81</td>
</tr>
<tr>
<td>Law clerks</td>
<td>0.91</td>
<td>2.69</td>
</tr>
<tr>
<td></td>
<td>0.75</td>
<td>1.84</td>
</tr>
<tr>
<td></td>
<td>0.76</td>
<td>1.41</td>
</tr>
<tr>
<td>Commercial clerks</td>
<td>0.97</td>
<td>2.66</td>
</tr>
<tr>
<td></td>
<td>0.75</td>
<td>2.65</td>
</tr>
<tr>
<td></td>
<td>0.76</td>
<td>2.92</td>
</tr>
<tr>
<td>Cotton operatives</td>
<td>1.26</td>
<td>2.86</td>
</tr>
<tr>
<td></td>
<td>0.84</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>0.78</td>
<td>1.45</td>
</tr>
<tr>
<td>Woollen operatives</td>
<td>1.27</td>
<td>2.70</td>
</tr>
<tr>
<td></td>
<td>0.69</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td>0.86</td>
<td>1.85</td>
</tr>
<tr>
<td>Hosiery operatives</td>
<td>1.48</td>
<td>4.02</td>
</tr>
<tr>
<td></td>
<td>0.60</td>
<td>2.35</td>
</tr>
<tr>
<td></td>
<td>0.83</td>
<td>2.04</td>
</tr>
<tr>
<td>Dock labourers</td>
<td>1.28</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>0.42</td>
<td>1.67</td>
</tr>
<tr>
<td></td>
<td>0.69</td>
<td>1.33</td>
</tr>
<tr>
<td>Costermongers</td>
<td>1.14</td>
<td>3.81</td>
</tr>
<tr>
<td></td>
<td>0.93</td>
<td>3.00</td>
</tr>
<tr>
<td></td>
<td>1.11</td>
<td>2.23</td>
</tr>
<tr>
<td>Tin and lead miners</td>
<td>1.10</td>
<td>3.21</td>
</tr>
<tr>
<td></td>
<td>0.58</td>
<td>1.54</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
<td>0.31</td>
</tr>
<tr>
<td>Sandstone masons</td>
<td>0.20</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0.85</td>
</tr>
<tr>
<td>Limestone masons</td>
<td>1.00</td>
<td>0.85</td>
</tr>
<tr>
<td>All iron miners</td>
<td>1.43</td>
<td>0.78</td>
</tr>
<tr>
<td>ditto</td>
<td>0.82</td>
<td>0.57</td>
</tr>
<tr>
<td>Iron-ore miners</td>
<td>0.50</td>
<td>0.74</td>
</tr>
<tr>
<td>All other iron miners</td>
<td>0.48</td>
<td>0.70</td>
</tr>
<tr>
<td>Boiler makers</td>
<td>0.49</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>0.21</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>0.33</td>
<td>0.78</td>
</tr>
<tr>
<td>Slate-quaeriers</td>
<td>1.16</td>
<td>2.43</td>
</tr>
</tbody>
</table>
been impaired in the battle of life; this
idea, however, hardly accords with ex-
perimental work which portrays silica as
exerting a specific influence favourable to
tuberculosis: such an influence should
make itself felt soon after it comes
into play; yet phthisis among sandstone
masons from ages 15 to 24, and among
tin and lead miners up to age 20, is rather
less than more prevalent than usual.
Possibly this absence in early years of
any undue prevalence of phthisis in these
industries is due to a combination of two
influences; in the first place, the con-
ditions in these industries do not favour
the transmission of infection; secondly,
are much smaller, 1 μ and less. These
particles in the alveoli are engulfed by
macrophages which then either move
within reach of the ciliated epithelium
lining the bronchioles when they are
expelled in mucus, or pass through
the walls of the alveoli into the pul-
monary lymph spaces. The macrophage
cells take up some forms of dust, such
as coal, far more readily than other
dust, such as silica. Particles of dust
too large to obtain access to the alveoli
are caught on the walls of the air
passages and expelled in mucus.

FIG. 160. — Moderate degree of simple silicosis. The lung shows considerable excess of pigmentation,
with moderately numerous "small" to "medium" sized palpable silicotic nodules. (According
to L. G. Irvine and W. Stewart, Johannesburg.)

evidence supports the view that tubercul-
ous silicosis is less infectious than or-
dinary pulmonary tuberculosis to persons
not the subjects of silicosis; hence new-
comers would have to develop some
degree of silicosis before becoming liable
to infection from their fellows. (See article
"Gold Mines ".) 

PATHOGENIC FACTORS

Size of Dust Particles

In order to gain access to the
alveoli of the lungs, dust particles must
be below a certain size, roughly 5 μ
in diameter; the majority of particles

Action of Silica Particles

Many forms of dust when carried
into the lymph channels remain inert
and unchanged (unless, like limestone,
they pass easily into solution and are
so removed); particularly is this so in
the case of carbon particles which can
be seen lying in physiologically healthy
tissues. Silica dust behaves differently;
the fine particles have in relation to
their size an enormous surface exposed
to the surrounding medium, and a
variation in the normal laws of solu-
ability is to be expected; even in distilled
water the rate of their solubility is
relatively high and rapid. Silica in
solution forms a colloid, and possesses
definite toxic properties; an overdose
of solution or of dust injected into
animals produces death. Smaller doses
produce local necrosis which is fol-
lowed by the formation of fibrous
tissue. When silica dust is inhaled the
macrophages carrying the particles out
of the alveoli are poisoned. They
appear to become mummified and die
without breaking up. These cells
collect in the lymph nodes and glands
where the toxic process continues and
affects the surrounding tissues; the
reaction of the poisoned tissues takes
coalesces with its neighbours; finally
the alveoli in large areas become
equipped. As the condition
progresses, the X-ray appearances
become more distinct and what were
at first small punctate spots become
larger and denser shadows dotted fairly
symmetrically over the two lungs.
Shadows branching into a network
and marking out the course of the
pulmonary arborisation are present,
just as they are present in the case of
other dusts associated with bronchitis,
but not with tuberculosis; these shad-
oows tend to be obscured in advanced

Fig. 161. — Very well-marked degree of silicosis, with many large irregular nodules and some
areas of fibroid consolidation. No overt tuberculosis. (According to L. G. IRVINE and
W. STEUART, Johannesburg.)

the form of a multiplication of fibro-
blasts which block the lymph channels
and wall off the noxious particles.
Thus there are formed symmetrically
in the lungs on both sides a vast
number of fibrous foci or pseudo-
tubercles which at this stage may be
detected by X-ray examination. Each
focus by blocking the lymph channels
forms a centre where more dust-bearing
macrophages collect, just as a branch
on a river caught against a rock
collects other debris and branches
brought down by the stream; the
process thus started tends to extend,
until one fibrous patch meets and
cases by more pronounced particulate
motting.
The process is usually more pro-
nounced at the apices and least at the
bases; the pleurae are always involved
and the fibrous formation affects the
parietal pleurae, so that extensive,
firm, tough adhesions are formed.
The formation of fibrous tissue may be
so rapid and extensive, that on section
the resulting nodules can hardly be
distinguished from fibromata; or the
process may be slower when contrac-
tion of the fibrous tissue becomes a
feature. In the first case so massive
is the fibrosis which may occur that
the lungs bulge out when the chest is opened after death as though they had had too little room; in the second they are found withered and contracted while bronchiectatic cavities may be present. The condition found depends on the extent of the exposure to dust inhalation and on the period intervening before death during which the fibrous tissue has had time to contract. In this way a condition of diffuse, symmetrical, chronic fibrosis, or pulmonary silicosis comes into existence; work, has been made that silica exerts its action by passing into solution in the body, when it becomes a tissue poison. When such a solution is introduced into the body it is eliminated by the kidneys which become acutely inflamed, while the liver also is affected. The possibility of small amounts of soluble silica escaping from the lungs into the circulation to be eliminated by the kidneys in cases where silica dust has been inhaled, must be contemplated; in some individuals such action may be more pronounced than in others, and, if so, the kidneys would tend in time to develop a fibrotic condition which would terminate as Bright's disease. Here is a possible explanation of why among those exposed to silica dust, e.g. tin miners and sandstone masons, the mortality from Bright's disease is high. Moreover, English mortality records for 1921-1923 display such high death rates from myocardial diseases among groups ex-

Fig. 162. — Gross fibrosis, partly infective in type. (According to L. G. Irvine and W. Stewart, Johannesburg.)
posed to the silica-dust hazard as to suggest that degenerative changes in the heart muscle also result.

SYMPTOMS

The symptoms exhibited will depend on the extent to which the disease has advanced; the rapidity of advance varies directly with the intensity of, and period of exposure to, dust inhalation. Even in a rapid case the advance, spread over several years, is comparatively slow and chronic, while the inch; the first heart sound on the right side may be accentuated. The arterioles in the front of the chest may be dilated. The man has a cough, paroxysmal in type, and frequent at night, but sputum is scanty, although haemoptysis may occur. A history of pleuritic pain is frequently given. In old-standing cases where fibrous contraction has occurred, both the heart and liver may be more exposed than usual, but the development of emphysema may mask this effect; in cases of rapid and massive fibrosis the opposite con-

FIG. 161. — Gross fibrosis, silicotic in type. Advanced silicosis. (According to L. G. Irvine and W. Stuart, Johannesburg.)

disease may take more than twenty years to develop when the dust-risk is not intense. Even a pronounced case may look robust, feel well, and be able to work, except for getting rapidly out of breath on exertion; he is unable to breathe deeply, and his respiratory action is entirely carried on by the diaphragm, the intercostal and extraordinary muscles of respiration not playing any part. Chest expansion at the nipple line seldom exceeds half an inch; the first heart sound on the right side may be accentuated. The arterioles in the front of the chest may be dilated. The man has a cough, paroxysmal in type, and frequent at night, but sputum is scanty, although haemoptysis may occur. A history of pleuritic pain is frequently given. In old-standing cases where fibrous contraction has occurred, both the heart and liver may be more exposed than usual, but the development of emphysema may mask this effect; in cases of rapid and massive fibrosis the opposite con-

dition may be found. Blood pressure is usually above normal; the number of red corpuscles is increased. Finally the heart dilates under the extra strain thrown upon it, and cardiac failure, sudden or more protracted, ends in death.

Tuberculous Infection

Cases of uncomplicated pulmonary silicosis may end fatally, but in the majority of cases the progress of the
pathological condition is interrupted by tuberculosis infection. The exact reason why subjects of pulmonary silicosis are especially liable to tuberculosis still awaits explanation, but silica appears to exert some specific influence in this direction not exerted by other agencies which cause pulmonary fibrosis. Kettle has established by experiments on animals that tissues which have been damaged by the presence of either fine silica dust or colloidal silica provide a more favourable nidus for tubercle bacilli than tissues similarly damaged by other factors; while Gardner has shown that silica dust, when inhaled, is more potent than any other dust in reactivating quiescent tuberculous lesions in the lungs. Gardner further holds that only silica and some silicates are capable of exciting significant reactions in the connective tissues of the lungs.

The course taken by tuberculosis in these cases is modified somewhat by the existing pathological condition; haemoptysis and night sweats are less common; pyrexia is less pronounced; and sputum is less copious than at a similar stage of ordinary pulmonary tuberculosis. Nevertheless, although the symptoms resemble those of a chronic type of the disease, the course taken is frequently rapid and very often fatal.

The question has been discussed as to when the tuberculous infection occurs. The sudden alteration for the worse in a case of simple silicosis which betrays the presence of tuberculosis, suggests that the infection may be a new thing not previously present. Another hypothesis, however, has been put forward, viz. that the infection is not necessarily new, but may have occurred when the dust particles were originally inhaled and have remained within the fibrotic centre of the pseudo-tubercles. Probably both types of infection occur. When present from the commencement, the fibrotic centre shows early signs of necrosis; when the infection is superimposed later, a firm necrotic centre may be found surrounded by necrotic tissue containing giant cells and tubercle bacilli. But every stage between the two may occur; thus an infected necrotic centre may break down and release its bacilli to be superimposed on non-infected fibrous nodes. Both hypotheses presume infection taking place during adult life through direct inhalation.

A condition of silicotic fibrosis undoubtedly paves the way for pulmonary tuberculosis; on the other hand, the occurrence of tuberculous infection hurries on or, as it were, precipitates a latent condition of silicosis. The two diseases play one into the hands of the other.

Differential diagnosis between the two conditions is often a matter of some importance; the following points when taken together are distinctive:

**SIMPLE SILICOSIS**

Fever absent.
Pulse normal.
Blood pressure raised.
Night sweats absent.
No loss of weight.
No malaise.
Sputum negative for tuberculosis.
Dyspnoea on exertion pronounced.
Toxaemia absent.

**SIMPLE PULMONARY TUBERCULOSIS**

Fever present.
Pulse rapid.
Blood pressure not raised.
Night sweats present.
Loss of weight.
Malaise present.
Sputum positive for tuberculosis (not necessarily).
Dyspnoea only in advanced cases.
Toxaemia present.

**Radiographic Appearances**

Particulate mottling.
Bilateral and symmetrical.

**Blood Count**

Haemoglobin normal or raised.
Red cells increased.
Leucocytes normal.
Polymorphonuclear cells normal.

**Other Dusts and Fibrosis**

Clinical observations and examination of mortality statistics for occupations with risk of exposure to dusts other than silica brought to light others (apart from asbestos, which is dealt with in a separate article) concerning which the evidence is at least suspicious.

**Oxide of iron (Fe₂O₃).**—The first instance to be quoted is provided by
iron-ore miners, even though like coal miners, their total phthisis rate is not high. English statistics for mortality among iron-ore miners were not separated from those for iron-stone miners before 1910-1912; nevertheless the figures for the whole group have always exhibited a definite rise in the phthisis mortality in the later years of life. For 1910-1912 this phenomenon was not found among iron-stone miners, but only among iron-ore miners, which suggests that in the two previous decennial periods the phenomenon was due to the inclusion of iron-ore miners with iron-stone miners; iron-stone is carbonate of iron; iron-ore is oxide of iron, \( \text{Fe}_2 \text{O}_3 \), but the ore contains a proportion of silica. Iron-ore miners have high mortalities from bronchitis and pneumonia; their mortality from Bright's disease is definitely above that of iron-stone miners, but it is not excessively so. The picture presented resembles that for coal miners on coal-fields where the phthisis rate is comparatively high.

Examination of certain iron-ore miners by X-ray disclosed the presence of punctate shadows varying directly in intensity with length of exposure to dust. Later, when one of the men died from pulmonary tuberculosis, the upper parts of his lungs showed definite whorls of fibrosis obliterating the alveoli; the fibrous tissue gave a definite reaction when stained for iron, a reaction not given by healthy parts of the lungs or by the red cells. The pathological evidence favoured the assumption that the fibrosis found was originated by the iron-ore dust to which he had been exposed, but the presence in the dust of a certain amount of silica must be kept in mind.

Another industry with exposure to dust of oxide of iron is that of boiler-making; in this instance no silica is present. Here also the age of maximum incidence of phthisis mortality has been uniformly late in life, even though the total mortality has not been high. The mortalities from either bronchitis or pneumonia, or from both together, at each decadental period have been high. That from Bright's disease is less definite. Here again, as in the case of iron-ore miners, is found in less pronounced form the statistical characteristics already quoted as distinguishing mortality in "silica" groups.

Alumina.— The dust of alumina, \( \text{Al}_2 \text{O}_3 \), calls for consideration because this substance, like oxide of iron and silica, in solution forms a positive colloid; if, therefore, silica and oxide of iron exert their influence by chemical action, alumina might be expected to resemble them. An occupational group exposed only to dust of alumina is not easy to find; thus potters, exposed to dust of china clay, are also exposed to dust of flint (silica). The best available example is the group slate-quarriers, but their mortality statistics have only been kept distinct for 1910-1912. The claim has often been made that slate-quarriers suffer from fibroid phthisis and pathological findings of definite fibrosis have been put in evidence. But the absence from the industry of any obvious undue prevalence of phthisis, such as occurs among tin miners, sandstone masons and grinders of metal, notwithstanding the amount of exposure to dust, caused the question to be left sub judice. Now, however, that fairly reliable figures are available, the phthisis mortality is found to be above normal and the age of maximum incidence is quite definitely in late life. The industry of slate-quarrying is carried on in North Wales where the age distribution of the phthisis mortality for males differs from that of the slate-quarriers. No excessive mortality is present among the men for bronchitis, pneumonia or Bright's disease; but dust of slate may not overtax the bronchial mucosa in the same way that does silica and other dusts, nor is it known whether colloidal alumina is excreted from the kidneys. The evidence, however, is in favour of slate-quarriers experiencing some amount of pulmonary fibrosis and exhibiting a mortality from phthisis which resembles that of "silica" groups in being highest in late life; in other words it is not unfavourable to the view that dust of alumina may exert an influence upon the pulmonary tissue akin to that exerted by silica.

Experiments in which animals were made to inhale dust of pure china clay tend to confirm the statistical evidence that dust of alumina reacts with living tissue in the same way as silica, even though the reaction is less pronounced.

Coal dust. — Investigation has disclosed that on British coal-fields mortalities from pulmonary diseases among miners are below normal on some fields, but are high on other fields. Bronchitis, pneumonia and tuberculosis vary together on these fields; but tuberculosis is never so excessive as bronchitis may be. While these variations are in some degree accounted for by the amount of sandstone rocks which may have to be manipulated in getting to the coal seams with consequent exposure to silica dust, there is...
evidence that the dust of anthracite coal induces a form of pulmonary fibrosis in every way similar to that induced by silica except that it does not prepare the way for tuberculous infection; dust from bituminous coal, on the contrary, does not induce such fibrosis.

In each of the above three injurious dusts, however, small, but varying, proportions of silica in the form of quartz particles are present in the respective minerals, and may be responsible for their toxic properties.

**LEGISLATION**

*Compensation for Silicosis and Tuberculosis*

**Argentina and Brazil.** — Compensation is granted in respect of tuberculosis.

**Australia.** — Compensation is granted (i) in New South Wales for silicosis or other disease of the lungs due to dust by the Silicosis Act, 1911 under which a scheme has been made for the sandstone workers in the County of Cumberland, and by the Broken Hill Acts, 1920 and 1927, under which uncomplicated tuberculosis is also compensatable; and (ii) in Queensland for silicosis; while the matter is under consideration in Western Australia, Victoria and Tasmania.

**South Africa.** — Compensation for pulmonary silicosis or tuberculous silicosis was first awarded to underground workers in South African gold mines. The first Act, which was passed in 1911, was modified several times before the present Act, the Miners’ Phthisis Act, No. 35, 1924, was adopted. The Act of 1919, No. 40, recognising three stages in the disease: (a) ante-primary, wherein damage to the lungs has occurred short of definite physical signs of silicosis, (b) primary, wherein physical signs of silicosis are present sufficient to impair capacity for work although not seriously or permanently, (c) secondary, wherein the physical signs of silicosis are sufficient to impair capacity for work seriously and permanently.

A fund is raised by a levy on each employer assessed as follows:

(a) 30 per cent. of the amount in proportion to the earnings in a scheduled mine during the previous period of three months of the miners employed by such employer;

(b) 50 per cent. of the amount in proportion to the silicosis rate for each mine;

(c) 50 per cent. of the amount in proportion to the sum for which such employer was assessed for normal income tax during the penultimate accounting period.

A Board is appointed to administer the fund, but on all purely medical questions the advice of a Medical Bureau must be accepted.

Any person wishing to work underground must undergo an initial medical examination, and miners must be examined periodically every six months. At any examination any man found affected may be suspended from work, when if he has been employed for at least two years, compensation is awarded, the benefit varying with the stage of the disease; tuberculosis not complicated by silicosis is ranked for compensation as the primary stage.

The Act contemplates that its provisions throughout will be worked by the industrial machinery constituted without any reference to the ordinary courts of jurisdiction.

For compensation of bricklayers and stonemasons, see article “Building Trade”.

**Canada.** — Compensation has been granted (i) in Ontario since 1926 for silicosis and other pulmonary diseases due to dust occurring in mining, quarrying, crushing and grinding stone, and in grinding metal; (ii) in Quebec, since 1931 for silicosis and miners’, stonecutters’ and grinders’ phthisis; (iii) in Alberta since 1925, for miners’, stonecutters’ and grinders’ phthisis; and (iv) in British Columbia and Nova Scotia if the workman can prove that the disease arose out of his occupation.

**Germany.** — Compensation is granted according to a schedule of industrial diseases, which includes a severe disease of the lungs due to dust (silicosis, or tuberculosis accompanying silicosis) in (a) sandstone quarrying and dressing, (b) grinding of metals, (c) pottery works, (d) mining.

**Great Britain.** — Fibroid phthisis or silicosis is recognised in Great Britain as a specific trade disease in certain industries, and special legislation has been passed with a view to provide compensation for this disease. It was not found possible to schedule it under the general Workmen’s Compensation Acts owing to the slow development and other special features of the disease.

Under the Act of 30 July 1918 (since embodied in Part II, section 47, of the Workmen’s Compensation Act, 1925, and in the Workmen’s Compensation (Silicosis and Asbestosis) Act, 1930) power was obtained to deal with the disease by special schemes for particular industries or processes involving exposure to silica dust. These Acts do not themselves require payment or compensation to workers killed or disabled by silicosis, but it lays down certain principles for inclusion in any scheme. Thus it provides for the establishment of a general compensation fund to which all employers in the industries should be required to subscribe and out of which all claims for compensation and all expenses arising under the scheme should be paid. In this way the burden of compensation is borne, not by the individual employer, but by the industry as a whole. They also provide
for the appointment of Medical Boards with expert knowledge of respiratory diseases for the purpose of making medical examinations and giving the necessary certificates and for the appointment of local joint committees representative of both employers and workmen in the industries with an independent chairman, who are entrusted with the settlement of claims and other matters arising under the schemes.

The Acts require that the scales of compensation shall, as regards silicosis or silicosis accompanied by tuberculosis, be those prescribed in the general Workmen's Compensation law. No provision is made in the Acts for compensation for tuberculosis unaccompanied by silicosis.

A scheme may also provide for the determination of any dispute arising between employers and the authority administering the compensation fund either by the Secretary of State or by an arbitrator.

In addition to providing for compensation, the legislation is of a preventive character in that it gives power to prescribe a standard of physique for all new entrants into the industry concerned and provides for a system of periodical medical examination and suspension, designed to secure the removal of a workman affected by silicosis or tuberculosis as soon as it becomes dangerous for him to continue work in the industry.

A scheme under these Acts for the refractories industries has been in force since 1 February 1919, and has recently been amended in accordance with the recommendations made by a Departmental Committee. The refractories industries are a group of industries engaged in the getting, handling, moving, breaking, crushing, grinding, and sieving of material containing not less than 80 per cent. total silica, and in the manipulation of such material in the manufacture of brick, or other articles for lining furnaces.

During 1929 somewhat similar schemes were made extending the provisions of the Acts to other industries, including (a) the metal-grinding industries, in which metal articles are ground on sandstone wheels; (b) the sandstone industry, in which sandstone is got or manipulated; (c) processes in mining and quarrying, in dressing and carving, in crushing and sieving, silica rock, i.e. quartz, quartzite, ganister, sandstone, gritstone and chert, and in crushing and grinding flint; (d) foundries and metal workers in the processes of crushing or grinding silica rocks or silica bricks, or in dressing or sanding of castings; (e) the granite industry; (f) the potteries with regard to exposure to flint dust; (g) tin mining; and (h) the asbestos industry.

The right to compensation under any scheme is afforded the worker or his dependants in cases of (1) death, (2) total disablement, (3) suspension from employment by reason of a diseased condition, which may or may not involve incapacitation for work rendering it dangerous for the workman to continue in the industries. In every case it is dependent on a certificate being issued by the Medical Board appointed under the scheme.

No compensation is payable in cases where the Medical Board certifies that the silicosis cannot have been contracted in the respective industries owing to the shortness of the time during which the workman has been employed therein, nor if the workman has left the industries, unless it is proved that since his last employment he has not been employed in any of the specified industries and occupations involving exposure to silica dust, which have otherwise been brought within the scope of the Acts.

Furthermore, the right to compensation is subject to the reservation that it shall be the duty of every workman:

(a) to submit himself to the periodic and other examinations provided for under any scheme;

(b) to furnish true information with respect to his previous employment in the particular industries or in any industry or occupation involving exposure to silica dust;

(c) not to re-engage in the particular industries after having been suspended under the scheme in force.

If, however, the worker acts in good faith and fails to comply with the foregoing requirements it has been due to circumstances outside his control, such circumstances being left to the judgment of the court, compensation may be paid.

The schemes vary somewhat for different industries; that for the refractories industries, which is the oldest and most complete, may be quoted.

Under pain of an increase in their subscriptions, employers are required to arrange for the initial examination of newly-engaged workmen, to furnish facilities for the prescribed examinations, and not to employ any workman who has been suspended or has refused to submit himself to any periodic medical examination (paragraph 43 of the scheme).

The general compensation fund required to be established under the scheme is administered by a company registered as the Refractories Industries Compensation Fund Limited, whose duty it is, subject to any directions of the Secretary of State, to fix, levy, and enforce all subscriptions which may be necessary to enable the fund to meet its liabilities. At present every employer engaged in the industries is required to pay a fixed rate per cent. of the wages earned by him in the industries, but the scheme gives power to the Secretary of State to require the company to adopt different rates of levy for different risks.

In addition to the compensation payable in the case of death or disablement, provision is also made for payment of two weeks' full pay and half wages for a further period not exceeding eleven weeks for a workman who has been suspended before their general physical capacity is impair-
ed, and for the payment of removal expenses not exceeding £5, if on suspension a workman is compelled, in order to obtain other suitable employment, to remove from the district (paragraph 7 of the scheme). An award may be reviewed by a Joint Committee if the condition of health or the circumstances of the worker undergo any change or for any other reason (paragraph 8).

The working of the scheme on the medical side is entrusted to a Medical Board consisting of two or more experts in respiratory diseases who are appointed by the Secretary of State (paragraph 3). They have power to make or cause to be made radiographic examination of any workman and to obtain the opinion of a radiologist on the case.

The scheme is not a rigid one, as it may be modified by subsequent Orders published in pursuance of the law, but it is interesting to note that the Departmental Committee regarded the scheme as amended as a suitable basis on which to frame schemes for the other and larger industries for which schemes have since been made.

Mexico. — Compensation is granted in respect of silicosis and tuberculosis. United States of America. — Compensation is granted in most of the industrial States of America for “diseases arising out of employment”, but silicosis is in no instance specifically named in any schedule of occupational diseases; hence the onus of proving that his disease has, in any instance, been caused by his occupation rests upon the worker.

See also the articles “Pneumoconiosis”, “Stoncutters”, and “Coal Miners’ Diseases”.

The problem of compensation for tuberculosis of occupational origin is, however, a much wider one than provided for by the scope of these laws and calls for detailed study. Yet since the basic principles of compensation are the same for other types of infection to be studied in the light of occupation, it appears preferable to deal with this question thoroughly in the special article devoted to compensation for occupational diseases [See article “Occupational Diseases (Compensation)”].

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Tumours of Occupational Origin and Occupational Cancer


The term “occupational tumours” is applied to cancers which originate from the regular and prolonged exercise of an occupation. This article will therefore not deal with tumours incurred by workmen as the result of accidental injury sustained during their work, for in these cases the appearance of the tumour can in no way be attributed to the nature of the occupation.

The object of this study is to combine and co-ordinate in one general description all the occupational tumours which have been dealt with in such different articles of this Encyclopaedia as “Arsenic”, “Tar”, “Pitch”, “Aniline”, “Anthracene”, “Naphthalin”, “Tumours of Occupational Origin: Urogenital System”, and Roggen Ray Operators (Industrial Pathology of), and to discuss particularly their pathogenesis and etiology — a matter which more especially concerns industrial hygiene.

The connection between cancer and occupation is alluded to in the publications of Vesiliius, Von Forest, and Ramazzini; but credit for the first scientific observation is due to Percival Pott, who in 1775 described scrotal cancer among English chimney-sweeps. Since then there have been numerous investigations, and the list of occupational tumours has increased. Volkman has identified the cancer of tar and paraffin workers with that of chimney-sweeps; and Manouvrier, of Anzin, has extended this resemblance to occupations concerned with coal and its by-products.

On the other hand, the discovery of X-rays and radium has enabled an undue incidence of malignant tumours to be observed among those whose occupation it is to handle them. Thus the progress of the knowledge of cancer and the more intelligent use of statistics have brought under suspicion certain occupations, wherein cancer, without appearing to be directly derived from or clearly connected with the handling of this or that product, occurs with a significant frequency.

This study will be a general review. No attempt will be made to consider the special aspect presented by each of the trades involved; descriptions of these varieties are to be found in the different special articles of the Encyclopaedia.

This general study is justified because occupational cancers not only possess common characteristics, but also a general behaviour which distinguishes them.

1 It would be more accurate to say “tumours caused by the exercise of an occupation”. The nomenclature “occupational tumours” has, however, been adopted because it is clear and everyone understands it. These advantages compensate for the incorrectness of the term adopted.
from other cancers, as well as a more definite aetiology, although it is still very incomplete, and also a better-known pathogenesis; and because measures for efficient prophylaxis can be more easily realised than in other forms of cancer. It is further justified because, generally speaking, these cancers have not been studied up to the present time with the minuteness that ought to be given to the subject, while many of their characteristics have been passed over too lightly by investigators.

**General Study of Occupational Cancers**

Knowledge of the pathology of occupational cancers has radically changed during recent years in consequence of the new light which has been thrown on the origin and development of malignant tumours.

The somewhat simple conception that cancer originates from a previous irritation, which irritation is sufficient to cause the appearance of a new growth has been replaced by the conviction that, for a certain number of tumours at least, general changes in the body play a considerable part in their origin.

Instead of envisaging cancer as an element which is just added to the organism as the result of an irritation, it is regarded as the final result of a series of biochemical changes in the body. It becomes an integral part of a general reaction affecting the composition of the fluids of the body.

This subject is clearly inexhaustible; there shall merely be indicated the present-day tendency of cancerology, such as is found in the works of Waterman, de Roussy, Maisin, Slosse and Reding, Bayet, Dustin, and many others.

It is not known at the present time whether this conception applies to all cancers, but it is improbable, considering the variety of affections included under this heading. Yet henceforward it is certain that occupational cancers, or at least the most important of them, i.e. those arising from the by-products of coal, belong definitely to a group of neoplasms and definitely to those in which the demonstration of this preliminary change in the body fluids is the easiest and most evident, as will be seen further on. The importance that this conception of the origin of malignant tumours presents for prophylaxis can be grasped; as a matter of fact, if the malignant tumour is only the result of a preliminary irritation, prophylaxis will be concerned with the local irritation; this is what has been done too exclusively up to the present. If, on the contrary, occupational cancer is the final stage of a poisoning which alters the body fluids, then the prophylaxis of these tumours becomes chiefly that of occupational poisoning.

When put in this way, a real dilemma has to be faced and calls for closer examination. It is, however, a mistake to place the two conceptions in radical opposition. The conception of cancer as a disease arising from irritation and the conception of cancer as a general disease. In reality they are combined and complement one another, as will be seen further on, at least in the case of the occupational diseases dealt with in this article.

The biochemical changes in the body fluids which must be present if an irritation is to cause a cancer often occur without any external sign. They usually depend on delicate analyses of biological chemistry, remarkable examples of which will be found in the recent works of Waterman and Slosse and Reding.

It is not always the case, and just in the most important group of occupational tumours — that due to the by-products of coal — they manifest themselves, by distinctly visible signs.

Are these changes of a general kind sufficient to cause cancer? It seems not. As will be seen, it is necessary that upon this prepared ground an irritation of physical or chemical nature must be produced, or of both together. But it must constantly be borne in mind that, in the case of certain cancers at least, this irritation alone is not sufficient to cause the tumour; the ground must be prepared.

Thus is seen once for all that the general prophylaxis of occupational cancer has a double basis: the prevention of poisoning and of irritation.

**General Aetiology**

Their aetiology allows occupational cancers to be divided into two groups.

The first includes occupational cancers the cause of which is evident, such as those caused by the by-products of coal, e.g. soot, tar and anthracene oils, and those resulting from radiations from X-rays or radium.

In addition to these are formed those where radiation is only presumed to be the cause: for instance, the action of light in the case of sailors and agricultural workers, and again, the influences not clearly defined which determine an excessive cancer mortality in certain occupations, such as among brewers and furriers, without it being possible to determine exactly by what mechanism the tumours are produced. As a matter of fact, it is possible that
factors essentially outside the occupation come in, such as those resulting from the habits of alcoholism and smoking, which cannot be directly attributed to any occupation.

**STATISTICS**

General statistics of occupational cancer are extremely difficult to establish. The difficulties encountered are those common to all cancer statistics, viz., insufficiency of the information received; absence of uniformity of conditions in the same industrial group, and, to a much greater extent, in different groups; interplay of activating influences; the action of influences outside the occupation itself and resulting from habits, i.e. tobacco, alcohol and general hygiene; and the effect of hereditary receptivity.

In Great Britain the number of cases of epitheliomatous ulceration due to pitch, tar, paraffin and mineral oils, was: in 1926, 187 cases, with 49 deaths; 1927, 174 with 49 deaths; 1928, 175 with 59 deaths; 1929, 365, with 56 deaths; 1930, 194, with 36 deaths.

A study on the mortality from cancer, made by Young and Russell with the collaboration of Brownlee and Collis (1926), confirmed the close relation between certain kinds of cancer and certain occupational risks (chimneysweeps' cancer, cotton spinners' cancer). Such a causality relationship was not, however, proved to exist between certain kinds of internal cancer and certain industrial operations. It was observed in certain occupations that habits of excessive smoking and drinking — acquired, it was pointed out, as a result of the exercise of these occupations were important factors in creating a predisposition to disease. It was also noted that the incidence of syphilis in certain occupational groups appeared to have some connection with cancer of the tongue. The study also emphasised the difficulties of interpreting statistical records.

The British statistics for 1921-1923 are occupationally even more reliable; they give the following comparative figures:

<table>
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<tr>
<th>Occupations in which cancer occurs</th>
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<td>Least affected</td>
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<td>Millers.</td>
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<td>Dealers in wines and spirits.</td>
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<td>Engineering industry.</td>
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<td>Waiters (café, restaurants, etc.).</td>
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<td>Most affected</td>
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<td>Clay and stone industry.</td>
<td>Soldiers.</td>
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<tr>
<td>Chemical industry.</td>
<td>Sailors.</td>
</tr>
<tr>
<td></td>
<td>Compositors, etc.</td>
</tr>
</tbody>
</table>

*Standardised Mortality of Males Aged 20-65 Years from Cancer*

All occupied and retired males taken as: 1,000

All males: 985

Coal miners making and repairing roads: 1,072

Smelters, rollers, converters of iron and steel: 1,156

Glass-makers, brewers, tin and copper miners: 1,300 to 1,400

Brass finishers, cotton card tenders, slaters, drivers of horses, stevedores: 1,400 to 1,500

Pottery dippers and glazers, and kilnmen, glassblowers, puddlers, metal-grinders, bookbinders, gas-stokers, porters, musicians, chimneysweeps: 1,500 to 1,600

Cotton-spinners, hat-formers: 1,600 to 1,700

Tin and copper miners: 1,885

Barmen: 2,100

Cellarmen: 2,801

Cutlery grinders: 2,938

Waiters: 2,953

When cancer of the skin only is considered, the following list contains occupations with highest ratios of "actual" to "expected" deaths.

**Deaths from Cancer of the Skin: Recorded Cases Expressed as Percentage of Expected Cases**

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Expected Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patent fuel workers</td>
<td>1,499</td>
</tr>
<tr>
<td>Cotton spinners</td>
<td>1,535</td>
</tr>
<tr>
<td>Chimneysweeps</td>
<td>1,667</td>
</tr>
<tr>
<td>Gas-stokers</td>
<td>250</td>
</tr>
<tr>
<td>Machine-composers</td>
<td>750</td>
</tr>
<tr>
<td>Cotton-carders</td>
<td>500</td>
</tr>
<tr>
<td>puddlers</td>
<td>467</td>
</tr>
<tr>
<td>Brick, etc., makers</td>
<td>389</td>
</tr>
<tr>
<td>Hat-formers, etc.</td>
<td>364</td>
</tr>
<tr>
<td>Coke-oven workers</td>
<td>333</td>
</tr>
<tr>
<td>Skilled glasshouse workers</td>
<td>358</td>
</tr>
<tr>
<td>Hargemen</td>
<td>385</td>
</tr>
<tr>
<td>Coal-boat loaders, etc.</td>
<td>396</td>
</tr>
<tr>
<td>Cotton-doublers, etc.</td>
<td>950</td>
</tr>
<tr>
<td>Railway shunters</td>
<td>917</td>
</tr>
<tr>
<td>General labourers</td>
<td>153</td>
</tr>
<tr>
<td>Metal-moulders</td>
<td>174</td>
</tr>
<tr>
<td>Chemical workers</td>
<td>159</td>
</tr>
<tr>
<td>All occupied and retired civilian males</td>
<td>100</td>
</tr>
</tbody>
</table>

It is a somewhat curious fact that nearly all the occupations noted as of excessive skin cancer mortality record a cancer mortality for sites other than the skin also in excess of the average.

Behla and Kolbe have also studied occupations in which cancer occurs, and their figures may be summarised as follows:
According to British statistics for 1910-1912, cancer of the skin is located as follows in the occupations most affected.

**Face:** fishermen, bargemen, hosiery makers, gardeners, cotton-spinners.

**Ears:** fishermen, agriculturists.

**Lips:** agriculturists, plateayers, sailors, stablemen, engineering labourers, navigating seamen.

**Hands:** sailors, gardeners, agriculturists, blacksmiths.

**Nose:** workers at gasworks, bakers, coal-heavers, plasterers, potters, leather and brick makers.

**Tongue:** dressers, brushmakers, wire-drawers, cutlers, tobacconists, hairdressers, brewers, messengers, ironfounders.

**Oesophagus:** furriers, photographers, brewers, electric apparatus makers, scientific instrument makers.

**Stomach:** miners (iron, lead), slate quarriers, wool-sorters, cotton-weavers, electricity supply, and makers of cycles.

**Scrotum:** chimney sweeps, cotton-spinners, workers in the chemical industry, and costermongers.

As regards the situation on the scrotum, which is one of the most frequent for occupational cancers, it is interesting to give the result of a British enquiry, published in 1926, which analyses 539 cases of cancer among cotton-spinners; 75 per cent. were located on the scrotum. Systematic periodical examinations of pitch workers enabled Dr. Body the certifying factory surgeon at Middlesbrough, to report 11 cases of epitheliomatous ulceration localised on the scrotum among 220 workmen examined in 1926. The incidence of cancer of the scrotum among workmen in various occupations, expressed as an average annual death rate per million, England and Wales, 1911-1920, was as follows:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Death Rate per Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>General average</td>
<td>4.1</td>
</tr>
<tr>
<td>Coal miners</td>
<td>14.0</td>
</tr>
<tr>
<td>Coal-briquette makers</td>
<td>5.8</td>
</tr>
<tr>
<td>Farmers</td>
<td>1.9</td>
</tr>
<tr>
<td>Agricultural labourers</td>
<td>1.5</td>
</tr>
<tr>
<td>Carpenters</td>
<td>1.9</td>
</tr>
<tr>
<td>Fishermen</td>
<td>1.6</td>
</tr>
<tr>
<td>Carders, winder and twist-ers</td>
<td>27.5</td>
</tr>
<tr>
<td>Spinners</td>
<td>134</td>
</tr>
<tr>
<td>Chimney sweeps</td>
<td>534.3</td>
</tr>
<tr>
<td>Workers in coal briquette factories</td>
<td>608.7</td>
</tr>
</tbody>
</table>

**GENERAL SYMPTOMATOLOGY**

If the general characteristics of occupational cancer are reviewed, it is found that:

1. These tumours all belong to the group of malignant tumours of the cancer type. In the large majority of cases they are epitheliomatous; it is only exceptionally that endotheliomata and sarcoma are found.

2. These tumours should not be considered as isolated lesions, as is generally done in the case of other cancers. They are part of a general reaction developing by successive stages, of which the malignant tumour is only the final stage. This is a point of fundamental importance in the study of these tumours, and herein lies an explanation of the importance attached to symptoms in the precancerous period.

In the different groups of tumours about to be dealt with there is always found this preparatory general reaction. It differs, however, according to the kind of cancer considered: in the case of cancer from arsenic or the by-products of coal, it appears in the form of a general poisoning of the body; in the case of cancer from radiations, it retains as a characteristic local preparation which is detected by changes in the skin at the site which has been subjected to the direct action of the radiations. But one thing is certain — a tumour is never seen to appear isolated without preparatory signs.

It is essential to understand thoroughly and define clearly this preliminary stage before the appearance of the neoplasm, for it is impossible without it to have a true conception of the pathogenesis of these tumours, or to suggest logical and efficient measures of protection.

3. These tumours often appear early in life and are found at a period when cancer, especially of the skin, is as a rule seldom seen.

4. They are often multiple, which is rather rare for other cancers, apart from metastases.

5. They only appear after the occupation has been followed for a very long period.

**PATHOLOGY**

There shall first of all be examined occupational tumours in which the appearance of the neoplasm is a direct result of the trade carried on; and, in the second place, occupations with excessive mortality which seems to result from the trade, without, however, it being possible to establish a direct connection between the effect of that trade and the appearance of the tumour.

**Occupational Tumours the Direct Result of Occupation**

This aggregate of occupational tumours is composed of three principal groups, according as they are due to:

(i) *chronic occupational arsenical poisoning*; (ii) *such by-products of coal as*
soot, tar, pitch, aniline or anthracene; (iii) prolonged exposure to X-rays and to radio-active bodies.

First Group. — Chronic arsenical poisoning, whether its origin be medical, alimentary or occupational, gives rise to a general reaction which in a certain number of cases ends in cancer. The quantity of arsenic necessary to provoke this state, preparatory to cancer, and to develop it, is extremely small; and the tumour usually only appears after many years of working with or exposure to arsenic.

These last two facts cannot be too strongly insisted on, for, as will be seen further on, they apply also to cancer caused by the by-products of tar. They can be most easily studied in arsenical cancer.

Investigations made among patients suffering from an arsenical cancer due to the taking of medicine show as a matter of fact that the quantity of arsenic absorbed was extremely small, only amounting to some milligrammes a day.

A more important feature than the weight of the toxic metal is the necessity for a very long period of action; this explains the fact, which surprises some people, that large quantities of arsenical drugs do not cause tumours, even after two or three years' administration; this period is quite insufficient.

The general reaction is very constant: it is that of a very slow poisoning which impregnates and causes changes throughout the entire body before the appearance of the cancer; the different phases of this poisoning always follow one another in the same order.

First, there is hyperchromiasis; then follows hyperkeratosis, upon which the cancer develops.

The pigmentation are of two kinds: general hyperchromiasis, or arsenical melanoderma, and localised hyperchromiasis, exhibiting black spots and freckles.

Hyperkeratosis generally appears in the form of a flat patch, as palmar and plantar hyperkeratosis. This localisation on the palm of the hand and the sole of the foot is almost pathognomonic of chronic arsenical poisoning. Independent of this very characteristic form, hyperkeratosis may also appear in the form of localised warts. Attention has not in general been sufficiently directed to this last variety of hyperkeratosis, which is much less rare than is believed.

Fig. 164. — General arsenical pigmentation. (Note the contrast with the forearm of normal colour.)

FIG. 164. — General arsenical pigmentation.

Arsenical cancer presents a collection of distinct characteristics:

1. Arsenical cancer always develops on a pre-existing hyperkeratosis.

Fig. 165. — Localised arsenical pigmentation in the form of brownish spots (case from the epidemic of arsenical poisoning at Manchester).
2. The positions of the tumours are very characteristic. Just as the palms of the hands and soles of the feet are generally the sites of hyperkeratosis in chronic arsenical poisoning, so it is in these places that arsenical cancer most often develops. But, besides these situations, arsenical cancer develops with a special frequency on the genital organs and quite particularly on the scrotum. In the statistics of Dubreuilh, which include nineteen consecutive cases of cancer from chronic arsenical poisoning out of twenty-four different cancer situations, other than the hand and foot, cancer of the scrotum was found nine times and of the groin twice.

3. Arsenical cancer is multiple in a relatively high number of cases. Out of the nineteen cases of Dubreuilh, there were thirty different situations, with an average of nearly three for each case.

4. Arsenical cancer appears at a comparatively early age. The average age of its appearance is forty-six years. Hutchinson reports a case in a woman of twenty-four years.

5. The period necessary for the action of arsenic to cause cancer is a very long one. In cases where it has been possible to measure it, the exposure to arsenic extended over fourteen, twenty-five, thirty and forty-eight years (Dubreuilh).

As regards the kind of cancer, arsenical cancer is an epithelioma of the basal-cell or perickle-ceil type; and the last appears most commonly. If it is not treated in time, it frequently causes death by spreading to the glands, with metastases and final cachexia, just as with cancer from other causes.

The occupations which expose to the risk of arsenical poisoning are numerous (see article "Arsenic"), but by no means all cause cancer. The symptomatic picture — hyperchromiasis, hyperkeratosis, cancer — is only rarely complete; as a rule only the first stages are seen either because the poisoning by arsenic has not acted sufficiently long, or because it lacks an auxiliary existing cause, which would have given rise to general poisoning and enabled the arsenic to develop its carcinogenic power.

Also, whereas observations on arsenical cancer following the prolonged taking of arsenical medicines are comparatively numerous, observations on malignant tumours of occupational origin are, on the other hand, rare. Three cases of cancer of the skin from "sheep-dip" have been reported (see article "Arsenic") and some cases among workmen employed in the hand-
be found that it stands in the front rank in assisting to elucidate the problem of the origin of other occupational cancers especially those which are connected with the handling of by-products of coal.

Second Group. — As a rule cancers due to the by-products of coal among men working among tar, soot, pitch, paraffin anthracene or aniline, are described separately. This plan disregards the obvious aetiological and symptomatic unity of these cancers, all of which, with the one exception of cancer from aniline, appear with identical symptoms as to behaviour, situation and development. This similarity is striking and would be sufficient by itself to justify grouping all these tumours under one heading. But there is more: all these bodies capable of causing cancer, however different they may be in appearance, structure and chemical composition, are found, on final analysis, to be derived from coke, coal or lignite; this common origin makes it still more legitimate to group together the tumours which they cause under one family name, viz. that of cancers due to by-products from coal.

The credit belongs to Manouvrier, of Valenciennes, doctor to the Anzin collieries, of having in 1877 recognised the common nature of these cancers. This is what he said at that time: “The particular affections of gas-workers, of chimney-sweeps from coal soot, of men who tar iron bolts, of dyers of flannel-ette of poor quality using chlorohydrate of aniline, of glove cleaners who use benzine, and of workmen employed in factories of chemical products derived from coal, present curious analogies with illnesses caused by pitch. In fact, poisoning by pitch, a solid residue from the distillation of tar, is only one of the numerous forms of this poisoning by coal and its derivatives, to which it is proposed to give the name of coal poisoning.”

Some years earlier, Volkmann had recognised the identity of chimney-sweeps’ cancer with that caused by tar; but he did not arrive at such a far-reaching conclusion. His chief error was in not recognising that a general poisoning of the system was involved. Moreover, whatever may be the nature of the causative substance, it is a fact that general poisoning exists, and it was of considerable merit to have discovered and reported it. At the present time the similarity of the clinical picture seen among all workmen who handle by-products of tar, the characteristics of the tumour, similar in every case, whatever may be
the by-product handled, justify the consideration of all the cancers now being studied as the final phase of a general poisoning caused by by-products from coal.

The industries of the by-products of coal in which the occurrence of tumours among the workmen has been observed are numerous. They may be divided into three series.

(a) **Soot series**: chimneysweeps and packers of soot; gardeners who handle soot as a fertiliser;

(b) **Tar series**: tar distillers; bitumen in the tarring paper trade; bitumen workers and asphalters; men who tar iron bolts, railway sleepers and earthenware; workmen employed in the manufacture of anthracene and anthracene oils; and paraffin workers.

(c) **Aniline series**: some workmen in the aniline industry.

The following table shows the industries of coal by-products, in which the occupations where cancer has been noted are in italics:

<table>
<thead>
<tr>
<th>OCCUPATIONS USING BY-PRODUCTS OF COAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Heating.</td>
</tr>
<tr>
<td>Gas</td>
</tr>
<tr>
<td>Ashes</td>
</tr>
<tr>
<td>Soot</td>
</tr>
<tr>
<td>Ammoniacal liquor: industry of ammonia sulphate, used unaltered.</td>
</tr>
<tr>
<td>II Lighting.</td>
</tr>
<tr>
<td>Tar</td>
</tr>
<tr>
<td>Distillation of tar; tar distillers.</td>
</tr>
<tr>
<td>Light oils.</td>
</tr>
<tr>
<td>Ammoniacal liquor: sulphate of ammonia workers.</td>
</tr>
<tr>
<td>Tar distillers.</td>
</tr>
<tr>
<td>Light oils.</td>
</tr>
<tr>
<td>Tar distillers.</td>
</tr>
<tr>
<td>Ammoniacal liquor: industry of ammonia sulphate.</td>
</tr>
<tr>
<td>Tar distillers.</td>
</tr>
</tbody>
</table>

For the third group, see article "Röntgen Ray Operators (Industrial Pathology of)".

**SYMPTOMS**

The symptoms shown by workers in these industries affected with cancer are identical in their chief points. They only differ in certain details connected with the nature of the substance treated and with the special irritation which it causes.

After a certain length of time spent in the factory the workman's skin shows a general hyper-pigmentation, which is at first of an amber colour, deepening with the length of the period of work, until, after a few years, it may present the appearance of a true melanosis (fig. 171). Then after a certain time, which varies according to the industry, epithelial proliferations or keratoedema make their appearance, generally in the form of warts. Finally, in some cases cancer develops.

The *pigmentation* is of two kinds: general, in the form of diffuse melanosis (fig. 171), or localised, in the form of small lenticular macules, often having the appearance of pigmented spots (fig. 172).

*Hyperkeratosis* generally occurs in the form of warts (figs. 173 and 174), elongated or flat. They disappear sometimes spontaneously; more often they remain stationary; but sometimes certain of them become changed into epitheliomata.

In some cases, which are rare, but, as will be seen, are significant, hyperkeratosis of the palmar and plantar surfaces is seen (Kleyenberg, Dubreuilh, Bayet). This kind of cancer presents the following characters:

1. It develops on a pre-existing keratosis, i.e. on a wart or on thickened epidermis in a xerodermal area.

2. It is very frequently situated on the scrotum. In the statistics of Bayet, out of 10 cases of cancer from pitch there were 6 situated on the scrotum, or 60 per cent. (figs. 176, 177, 178, 181, 185 and 186). Liebe's figures relating to workmen at tar distilleries give, out of 14 observed cases of cancer, 10 situated on the scrotum; among mule spinners in English cotton mills the percentage is 75. According to a report by Schamberg, 18 out of 24 cases of cancer in chimneysweeps were situated on the scrotum, or 79 per cent.; and out of 22 cases of tar and paraffin cancer, 17 were situated on the scrotum, or 77 per cent.

It is remarkable that the proportion is almost the same for all these industries and trades in which the materials manipulated are so different from the point of view of physical structure and chemical composition.

In some industries where the contact with the irritating substance is chiefly
on the forearms, as in the case of men employed in handling paraffin, the statistics of Schamberg and of Liebe show that the situation of the cancer is frequently the scrotum. The other situations are in order of frequency the face (fig. 182), the forearm (fig. 184), the penis (fig. 170).

3. The cancer is often *multiple*. Out of 14 of Liebe's cases among paraffin workers, 2 had more than one site.

4. Cancer from by-products of coal frequently occurs early in life. Out of 10 pitch workers, 5 cases occurred at forty years and a sixth at forty-one (Bayet). Chimneysweep's cancer is found on an average between the ages of thirty and forty, in some cases between the ages twenty and thirty. Earle (the son) noted one case that appeared at the age of puberty. Earle (the father) saw a case of cancer occurring in an eight-year-old child who had been employed as a chimney-sweep. These extraordinary statements are explained by the fact that children used sometimes to be employed as chimney-sweeps when they were four and a half years old.

5. The date of the appearance of the cancer comes a long time after entering the injurious occupation; among paraffin workers it never appears until quite twenty years after the commencement of the occupation; among pitch workers and mule-spinners, the average period necessary before the appearance of cancer is forty years. So it is a question of very slow poisoning and a precancerous period of very long duration. Here again, as in the case of arsenic, the need is apparent for a very prolonged exposure to the injurious substance. It is, therefore, extremely probable that the quantity of this poisonous agent must be very small, as is the case with arsenic. Here, once more, appears this type of poisoning which is eminently chronic and evolves under the stimulus of extremely minute doses of the poisonous substance.

Such is the general reaction of tumours due to by-products of coal. But in each occupation there are differences which will now be described.

In the case of chimney-sweep's cancer, the scrotal position is by far the most...
In the case of tar-distillers and of those employed with paraffin, the forearm is the usual situation; but the scrotum is also very frequently affected. In the case of workmen who handle pitch, the position most often observed is the scrotum, next the face. These are only slight differences, which do not seriously alter the general symptomatic picture.

The same thing is not found with aniline. Here the symptomatic picture is so different from what results from the other by-products of coal that the tumours observed among aniline workers deserve a special description.

It was in 1895 that Rehn reported three cases of tumour of the bladder among workmen at an aniline factory at Frankfort-on-Main. Since then the cases have increased; the number of tumours from aniline reported up to 1926 was as high as 177. It is true that Curschmann analysing the cases reported since 1913 estimates that the number of authentic cases only reaches 28; but Leuenberger, who has studied the cases at the surgical clinic at Basle, found proof that sickness from cancer among aniline workers was far greater than the figures of Curschmann would lead one to suppose. The Prussian medical inspectors in 1925 reported a case of cancer caused by aniline; and in 1926 the English medical inspectors had heard of 4 cases, of which 2 were fatal.

Workers in aniline factories are not all equally exposed to the risk of tumours of the bladder. The conditions under which they work vary considerably, depending upon the department to which they are attached. As a matter of fact it is only a minority which is exposed to the risk of poisoning, for the manipulations are very often carried out in closed vessels. The figure of 177 cases observed is in reality quite small, if one bears in mind that the German aniline industry employs from 80,000 to 100,000 workmen. Nevertheless, it must not be forgotten that Rehn reported 3 cases of vesical tumours out of 45 workmen employed in a workshop where fuchsine was produced.

The products which according to different observers have been incriminated as being the cause of tumours of the bladder in aniline workers are the following: nitrobenzene, nitrotoluene, aniline, toluidine, fuchsine, benzidine, anthracene, naphthylamine, diphenylamine, xylidine and mixtures of these.

According to some authors, out of all these substances aniline and benzidine are alone responsible for tumours; and, even then, the part played by the latter is doubtful. On final examination aniline alone is responsible. It seems that the injurious products only act when they are in the state of vapour (Nassauer). According to the works of Rehn and Nassauer, the entry into the system takes place by inhalation of very fine aniline dust.
ing results, but at the present time the question still remains unsettled both as regards the aetiology and the pathogenesis (see later).

The type that tumours take in aniline workers is generally that of papilloma and carcinoma of the bladder. Out of 28 cases reported by R. Scheidler in his inaugural thesis he found only two of sarcoma and seven of benign papilloma. Vesical symptoms only appear on an average sixteen years after the commencement of work in the factory (Nassauer). The vesical tumours observed among these men show nothing which can distinguish them from those due to any other cause. (See article "Occupational Diseases: Urogenital System".)

S. Henry, N. M. Kennaway and E. L. Kennaway (1931) investigated the incidence of cancer of the vesicle and of the prostate in certain occupations by examining the death certificates issued in England and Wales from 1921 to 1928. In 8 out of 10 occupations involving exposure to coal, gas, tar, pitch, soot, cancer of the vesicle was found to be more frequent than among the rest of the male population. In 5 out of 10 of these occupations, this difference varied from one-half to four times. The findings on cancer of the prostate were less conclusive.

Quite independent of the vesical tumours, the workmen show premonitory symptoms to which it is important to draw attention. The earliest and most characteristic of these symptoms is profuse sweating on the hands with swelling of the back of the hand; it is a typical occupational condition of aniline workers. Next follows eczema of the hands, with superimposed papillomata, with a sharp outline, of the size of a pea, similar to what occurs on the arms of paraffin workers. Then, in some cases, a more acute cutaneous affection is found, generalised, with oedema, which affects the hands, face, ears and, in a remarkable way, the penis and scrotum. In some workmen handling aniline, hyperkeratosis has been noticed which has the appearance of papilloma.

Thus it is seen that the diseases caused by aniline differ from those of other by-products of coal, in the fact that a different situation is concerned which is closely related to a change in type. Papillomata are to mucous membranes the homologue of cutaneous warts and it is the degeneration of these papillomata which gives rise to cancer, just as that of warts causes cancer of the skin. Thus then, in spite of certain divergences in appearance, easily explained by the difference of the substances handled, aniline cancer, up to a certain point, conforms to the general type of cancer caused by the by-products of coal.
Aetiology

A fact which first strikes the attention, if the lesions caused by the by-products of coal are examined, is that in spite of the physical and chemical differences between the injurious substances handled by the worker from soot to anthracene, including tar, pitch and lamp black, the symptoms remain strictly identical in all.

This observation suggests in an overwhelming way the idea that there should exist, to explain this stereotyped train of symptoms, a single cause to be found in all the by-products of coal.

This is the idea which has naturally presented itself to all writers who have dealt with this question. They have successively blamed: phenic acid, creosote, ammoniacal vapours, naphthaline, coal from points of straw, and radioactivity.

When examining the foundation of these hypotheses, a fundamental observation must be recognised: before an agency can be assigned as causing poisoning by by-products of coal, such as can account completely for what occurs, it is obviously essential that this agency, separately applied to the body, should reproduce the symptoms which are so characteristic of this form of poisoning.

Now of all the causes mentioned above not one so far has fulfilled these conditions. Neither clinical observations, nor experiments have exhibited a disease entity which tallies with that manifested by workers among by-products of coal.

It is under these circumstances that, as the result of long and thorough investigations, A. Bayet, in collaboration with A. Slosse, of Brussels, basing his opinion on clinical observation, on comparison of observations and on biochemical analyses, has come to the conclusion that he has recognised the agency in arsenic, which is found in definite quantities in coal and is found in all the by-products. He feels warranted in developing at some length the arguments which in his opinion support his idea, not with the object of pressing his views, but rather with the intention of furnishing a basis for discussion on this point which is so important for prophylaxis. At the present time this is the only hypothesis supported by a group of arguments, which confers upon it a high degree of probability. The practical importance of this hypothesis, if it is found to be accurate, appears to its author to justify the developments which he has based on it. Arsenic as a matter of fact fills the requirements formulated above; it reproduces feature for feature the symptomatology of the by-products of coal. Not only are the symptoms identical in the two series, but they occur in the same order of succession.

The description of the symptoms just made, and comparison of the accompanying illustrations, are convincing. The following table makes this similarity clear at a glance.

**TUMOURS OF OCCUPATIONAL ORIGIN**

**CHRONIC ARSENICAL POISONING.**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Arsenical poisoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperkeratosis</td>
<td>Hyperkeratosis in flat form (rare). (Dubreuilh, Bayet).</td>
</tr>
<tr>
<td>Warts</td>
<td>Warts.</td>
</tr>
<tr>
<td>Cancer</td>
<td>Cancer developing on a keratosis. Considerable frequency of scrotal cancer. Early appearance of cancerous degeneration. Need of very prolonged action of the toxic agent before the appearance of the tumour.</td>
</tr>
</tbody>
</table>

This comparison shows that chronic arsenical poisoning reproduces exactly the lesions caused by the by-products of coal. Moreover, this finding is of the highest importance for occupational hygiene, for it gives weight to measures of protection which are applicable to the numerous industries in question.

On account of the importance of this conclusion, it is important to strengthen the comparative examination of the clinical symptoms by other considerations which support this view in an extraordinary degree.

First and foremost stands out, on the one side, unusual frequency of the localisation of cancer to the scrotum in chronic arsenical poisoning, and in that from the by-products of coal on the one hand, and, on the other, its great rarity in any other morbid group.

It has been seen how common this typical situation is in these two kinds of poisoning — about 70 per cent. of cases. Accurate statistics, on the contrary, show how exceptional this situation is, apart from this group of cancers; at the General Hospital at Vienna in eleven years, out of 2,400 cases of malignant tumours among men there was only a single case of

1 This idea had already been advanced by Dr. Smith in 1913. See his article "Arsenic Cancer", in the Lancet, July and Aug. 1913.
cancer of the scrotum; and at the General Hospital at Prague in nine years, out of 360 cases of malignant tumours in men again only a single case was found. At the Charity Hospital at Berlin in eight years a single case occurred.

It is then very significant that only two kinds of poisoning, that by arsenic and by the by-products of coal, cause a considerable proportion of scrotal cancers; and this statement demonstrates clearly that the facts are only explicable if for the two morbid groups reaction to the same causative agent be admitted.

Another fact perhaps still more convincing is the following: at the present time on account of hygienic measures adopted by modern methods, poisoning by the by-products of coal is slow, the symptoms are weakened, and the date of their appearance is retarded. But it has not always been so. Forty years ago the conditions under which briquettes were made were extremely defective and it was possible to observe cases of acute poisoning caused by pitch (see that article). Such cases were reported at the briquette factory of the Anzin collieries. The pitch arrived hot and fuming and was collected in pans open to the sky, where it cooled on contact with the air. Some of the workmen were employed to hasten the cooling by stirring the mass. During this manoeuvre acid and irritating vapours were liberated in profusion and were inhaled by the men. Further the dry pitch was crushed in a cellar, through the vent hole of which it was discharged. Hence there resulted a fine and abundant dust which penetrated everywhere, and into the respiratory and digestive passages of the workers.

The consequences of this impregnation of the system by the emanations of pitch were: bronzing of the skin, various eruptions, cancerous growths of the scrotum and face, similar to chimney sweeps' cancer, inflammation of the eye, defective eyesight, coryza, ulcerations of the nasal fossae, suppurations of the ear, bronchitis, digestive troubles with black motions and a particular coloration of the urine 1.

Here then are found, apart from symptoms which are common to chronic arsenical poisoning and to sickness caused by the by-products of coal, such as bronzing of the skin and cancerous growths of the scrotum, other lesions, including inflammation of the eye, defective vision, ulceration of the nasal fossae, suppuration of the ear, bronchitis, digestive troubles with black motions and abnormal coloration of the urine, all of which form part of the symptomatic complexus of subacute poisoning by arsenic.

Some of these illnesses are quite common place and are found in a certain number of workers employed on any kind of irritating substance: inflammation of the eye for example. But there is a sign which, by its rarity and its special situation, is absolutely characteristic of arsenical poisoning, viz, coryza with ulceration of the nasal fossae. It is sufficient when reading observations made on persons employed on Schweinfurt green (copper arsenite) to note the frequency of this sign in arsenical poisoning. Except for arsenic there are really only cobalt and the chromates which cause it, and there is no proof that traces of arsenic which they may contain are not the causative factor 1.

It is seen then that pitch can, under thoroughly defective conditions of occupational hygiene, cause subacute arsenical poisoning.

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1 Ulceration with perforation of the nasal septum, as caused by copper arsenite, can result from inhaling fine dust of sodium chloride or any other hygroscopic substance (Collis).
lamp black, or aniline, but also, in a comparatively large amount, in bituminous schists.

Further, he was able to point to the presence of arsenic in a strength two hundred times greater than the physiological strength in the hair, blood and urine of men working with pitch, and also to demonstrate that this arsenic is contained in the air of the workshop where it is carried about in the dust.

Two objections have been raised to this suggestion for interpreting the pathogenesis of occupational tumours.

The first objection is the statement of Ross to the effect that, according to analyses made at the Lister Institute, tar does not contain arsenic. This statement, accepted and repeated unchecked by authorities who are working on tar cancer, and particularly by Fibiger, who is an authority on the matter, has seemed sufficient to close the debate and lead to the rejection of the arsenic theory of the cancer. However, according to a statement by Dr. Ross himself, these analyses were not made in view of biological research, but to an end of industrial nature. In consequence they were not able to detect the comparatively small quantities of arsenic which tar contains, and which are only from 10 to 20 microns per kilo. These quantities have been detected by means of special methods never used before the work of Slosse in this kind of investigation 1.

The second objection is that of Fibiger, to the effect that the tar which he used to cause cancer in mice contained quantities of arsenic too small to cause a general poisoning. However, these quantities which Fibiger considers too small (3 mill. per kilo.) are of the same order of magnitude as those contained in tar. Then again there must be taken into account the fact that with man we are dealing with an impregnation lasting not months, but some tens of years.

The denials of those who refuse to accept the resemblance between cancer from by-products of tar and that from chronic arsenical poisoning are not based on sufficiently minute clinical analysis, nor on chemical analysis sufficiently delicate to be taken into consideration.

In endeavouring to make the two hypotheses agree, Gilbert (1919) was prepared to admit that the cancer producing power is not in the arsenic itself, but in a special arsenical compound 2.

As regards the tumours which occur among aniline workers, the proof of an absence of arsenic: (1) isoprene, (3) yeast, (4) human skin, to temperatures ranging from 700° to 928°. Acetylene is the simplest organic compound from which a carcinogenic material has so far been obtained. A petroleum which produced no tumours of any kind in mice in a prolonged experiment showed very active cancer-producing properties after exposure to a temperature of 880°. The cancer-producing substance present in coal tar is formed only in very small amounts below 450°; at 560° it appears in much larger quantity, and this increase continues at a slower rate up to 1,250°.

1 KENNAWAY has studied (1924-1925) experimentally the possibility of obtaining cancers in mice by means of substances obtained by heating: (1) acetylene (the acetylene used con-
arsenical origin for these tumours is, as a matter of fact, less obvious than that of the other tumours caused by by-products of coal. There can here only be indicated the arguments which might support this origin, without disguising the fact that the demonstration is less rigorous than the preceding. They are rather suggestions inspired by certain clinical analogies. Among those there is the general fact — already pointed out — that papilloma and carcinoma observed in the bladder are the homologues of the warts and cutaneous carcinoma arising from the other by-products of tar. Further, the cutaneous symptoms, comparison between which have generally been neglected, are somewhat similar in poisonings by aniline and by arsenic. Particularly is this the case with hyperhydrosis of the hands, so special to these workers. Moreover, this symptom is found to be quite as characteristic in arsenic poisoning. The presence of this symptom in the two diseases must be emphasised. It derives its significance by virtue of its rarity under other circumstances.

Eczema of the hands with deep ulceration, having clearly defined edges, makes one think of the ulcerations among workers on Schweinfurt green and even of those cases where the ingestion of arsenic takes place internally.

Finally, the acute oedemas of anilism closely resemble those of acute poisoning by arsenic, and, curiously enough, occur with quite a particular predilection on the scrotum. The bullous dermatitis of anilism is found in exactly the same form in arsenical poisoning; and anilism can cause hyperkeratosis, through this is rare. Here is found a collection of clinical facts which should attract attention. Let it be added that anilines always contain arsenic, that Wignale (of Manchester) found in the urine of aniline and benzi-
dine dye-workers traces of arsenic (0.03-0.2 mill. per 100 c.c.), and that in the opinion of A. Hamilton the vesical tumours of aniline workers can be attributed to arsenic, and, more particularly, to arsenic-hydrogen gas present during the reducing process. Thus there is a group of arguments worthy to be taken into consideration in judging of the final origin of tumours among aniline workers.

It is certainly difficult in a given case to separate what arises from internal action and what from external irritation. But a simplification of the solution of this problem must not be sought by attributing all the illnesses observed to the external action of the substances used, without taking into account the complete clinical picture presented by the workers. It would be too summary and simple to do so. As a matter of fact if the lesions which are produced under the influence of the internal administration of an arsenical product be examined, without the intervention of any external irritating action, such as chronic poisoning of medicinal origin, it is found that they appear in the following order: (1) general and localised pigmentations; (2) cutaneous eruptions; (3) hyperkeratosis in plaques or warts.

It is on these hyperkeratoses that cancer develops as we have seen. There is every reason to admit that it is the same with the absorption of arsenic from carrying on an occupation.

In the case of poisoning by the by-products of coal, this test is not possible; but there are means for separating the phenomena of general pigmentation which arise at the beginning of the period of work at the factory — generalised pigmentation — from those which only arise later, after a stay of two years — hyperkeratosis in the form of warts.

The pigmentations are a clear sign of poisoning of the body and have nothing to do with external irritation.
On the subject of warts, the argument might, if necessary, be advanced that they can be caused by external irritation; nothing is more plausible; but careful observation of facts shows that in the case of many of the sites it is impossible to attribute the condition to irritation, for the warts frequently occur on sites little exposed, such as the eyelids and the groin. It is possible that without preparatory poisoning the irritations would never cause warts.

The essential part of the symptoms which precede and prepare the way for the appearance of cancer depends on internal poisoning, that is to say, on that produced by the inhalation and swallowing of harmful dust. This is a statement to be utilised in the prophylaxis of cancer.

The slight comparative importance of external irritation is shown by the fact that the physical nature of the substance handled does not appear to have a pronounced influence on the appearance of cancer. The illnesses have no relation to the physical structure of the products handled. It is thus with soot, the consistency of which is very soft and almost impalpable; it cannot mechanically cause any irritation. Yet it is soot that causes the most definite sicknesses, while pitch from blast furnaces — the dust of which is angular, cutting and irritating — never causes cancer.

The following table drawn up by Ross furnishes the proof of this:

<table>
<thead>
<tr>
<th>Substance handled</th>
<th>Mechanical action</th>
<th>Incidence of cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas works pitch</td>
<td>Slight when it is soft. Liquid substance.</td>
<td>Considerable.</td>
</tr>
<tr>
<td>Tar.</td>
<td>None.</td>
<td>Several cases</td>
</tr>
<tr>
<td>Soot.</td>
<td></td>
<td>The most frequent of all</td>
</tr>
</tbody>
</table>

And again it might well be asked, if the causative agent was the physical
As regards external chemical irritation, it may be said that for many of the by-products of coal this irritation is very slight. If one excludes burning splashes it is not possible to prove it. If they really come into the case as the one and only cause of cancer, one may well wonder how it is possible to explain the similarity of action between substances so dissimilar chemically as soot, tar, and the mineral oils. The accumulation of soot in the folds of the scrotum has been blamed. Nothing is less proved than this assertion. In one briquette works, where 37 per cent. of the workmen were affected with cancer (Bayet), the workers take a soap bath each day and the dust is removed daily from their working clothes, and the medical examinations made during working hours have never revealed the existence of this accumulation in the folds of the scrotum.

But, if the external irritation has only a secondary part, its action must be taken into account all the same. However it is powerless by itself to cause lesions on a normal individual. Objections are raised to this statement in view of what happens in the case of mice which have been painted with tar: the cancer appears at the irritated place and this fact is quoted in favour of the possibility of the production of cancer from external irritation. But a careful study of the facts shows that the appearance of cancer is preceded in mice by a change in the general condition which leads to the production of neoplasms (Maison, Mertens, Roussy).

The usual course of what occurs in man can be thus formulated: general poisoning, which is necessary and precedes the appearance of the cancer; that is followed by degeneration of a hyperkeratosis which may be irritated or not, but it requires the preliminary existence of this general poisoning.

This course can be best seen in its development, freed from all accessory external action, in cases where warts and cancer develop in individuals who have left the factory a long time, sometimes for ten years, and have carried on occupations which do not give rise to any special irritation. In these cases the development of the disease has the value of an experiment.

OTHER CAUSES OF OCCUPATIONAL TUMOURS

1. Tumours have also been observed among workers who handle by-products in the distillation of bituminous schists. (See article "Shale Oil Industry").

Cancers found among mule-spinners are connected with cancers due to schists. (See article "Cotton Industry"). The Cancer Committee, set up at Manchester to study this question, has for several years been investigating the carcinogenic properties of mineral oils. According to its 1929 report, it has been found that, in the distillation of tars, the carcinogenic products begin to form at a temperature ranging from 500° to 600° C. and reach a maximum at between 800° and 900° C. The addition of sulphuric acid at the time of use suffices to make the oils harmless without injuring or modifying their lubricating power.

2. Some cases of cancer have been reported among petroleum workers. About thirty-three have been recorded in literature, most of them observed in Galicia. (See articles "Lignites", "Paraffin", "Petroleum").

Tumours are seen only as the result of prolonged exposure to X-rays or to radium. (See articles "Radium" and "Röntgen Ray Operators").

The cancer which occurs shows the characters which have been noted for industrial tumours in general; it develops on a hyperkeratosis; it is the end result of a precancerous local change; it is often multiple; it occurs early; it only appears after a prolonged period in the occupation. The persons exposed to risk are radiologists and those who handle radium, whether workmen, doctors applying radium for treatment, or hospital nurses (for luminous rays see later).

There should be noted here cancer among the miners of Schneeberg (Saxony), among whom the appearance of cancer is decidedly the direct and obvious result of the occupation.
The disease consists essentially of cancer of the lung with metastases (see articles "Cobalt" and "Uranium").

There have been reviewed the cancers which can, without any possible dispute, be connected with the exercise of an occupation. There are others where this connection is not so evident, but where the unusual frequency of cancer is bound to draw attention to a possible connection between the occupation and the existence of cancer.

In certain occupations the malignant tumours seem to be the result of handling a chemical substance (to be defined by further research); in others the cancer seems to be dependent on the action of physical agents.

In the first group are found:

1. Maltsters, Brewers, Publicans

It has been noticed that the mortality from cancer among brewers and maltsters (see article "Indiarubber and Chemical Industries") is much above the average. The proportion of deaths from cancer among them is 70 per 100,000 compared with 48 per 100,000 for the population in industrial districts and 47 per 100,000 of the general population.

In order to explain this high mortality, the variations of temperature to which these workers are subjected has been blamed, but without succeeding in justifying this effort at explaining the aetiology of these cancers.

Alcoholism has also been blamed. It is indisputable that alcoholism plays a certain part in the production of cancer in the upper part of the alimentary canal, as can be established by noting the frequency of cancer in the occupations where intemperance is common, for example among commercial travellers, tavern keepers, butchers and coachmen.

It may be noted, without dwelling further on the fact, that beer at times contains arsenic, glucose up to 0.08 per cent. and the sulphuric acid contained up to 1.4 per cent. of arsenic was found in arsenic contained in sulphuric acid used for the treatment of cancer. There is here a theory worthy of investigation.

The appearance of cancer is preceded by changes in the skin which resemble rodent ulcers and epithelioma of the skin, especially of the face, among these carriers of light, as confirmed by other authorities, atmospheric humidity is a powerful absorbing medium of X-rays, while light only plays a secondary part. The evolution of cancer from light certainly is relatively long.

Light appears to be the cause of tumours of the skin, especially of the face, among agricultural labourers, sailors and fishermen. In 1865 Thiersch put forward this theory, confirmed later by other authorities. Thus, for example, carcinoma of the lips and face have been found among agricultural labourers to account for 27 per cent., as compared with only 10 per cent. of all cases of cancer in the Vienna clinic. We know that the skin protects itself against the injurious action of light rays by pigmentation. But the direct action of ultra-violet rays on the cellular protoplasm leads to atrophy of the skin among even comparatively young persons, and the lesion (xeroderma pigmentosa) easily becomes carcinomatous. Through the recognised stages — hyperaemia, pigmentation, hyperkeratosis with atrophy — cancer is reached.

Lawrence (Australia) has recorded a relatively high number of cases of keratosis, rodent ulcers and epithelioma of the skin, which he attributes to the action of light aided by the slight humidity of the atmosphere. According to this authority, atmospheric humidity is a powerful absorbing medium of ultra-violet rays (1929).

Other experts, on the contrary, hold that some other cause plays a more important part in the aetiology of cancer, while light only plays a secondary part. The evolution of cancer from light certainly is relatively long.
PROPHYLAXIS

1. The prophylaxis of cancerous growths caused by by-products of tar is mixed up to a certain extent with prophylaxis of chronic arsenical poisoning and prophylaxis of the by-products of tar (see the articles concerning the different by-products of coal).

What has been said above emphasises the decisive part which general poisoning plays in the production of these tumours, dominating all prophylaxis. In drawing up prophylactic measures, especially in assigning to external action the exact place which belongs to it, account must above all be taken of the danger of general poisoning — the necessary and sufficient cause for the appearance of cancer. It is that which must be dealt with.

The ideal prophylactic of course lies in the abolition of dust. But it is difficult to realise this desideratum in practice, and, if attention be confined to considering the tumour, it may be claimed that it is not even necessary to go as far as total suppression; the same result may be obtained by reducing the amount of injurious dust present as near as possible to a definite limit.

Clinical observation has shown that there must be a certain quantity of injurious dust in the atmosphere of a factory to determine the formation of cancer. As a matter of fact, among pitch workers cancer was most common among those working in places where dust was most abundant (Bayet and Slosse).

When the quantities absorbed are small the course of the illness does not develop as far as cancer; this is the case for example with the men employed at gas-works, with those who work on lamp black, and those who work in the open air. With these the first symptom of a general poisoning, viz. hyperpigmentation, is found but not cancer. There is then some chance in this direction of avoiding cancer by reducing the quantity of arsenical dust inhaled.

Cessation of work, as has been seen, does not save the man from cancer. From the time a hyperkeratosis comes into being the workman is exposed to the eventuality of cancer, even if it is slow in developing. A well-arranged prophylaxis must therefore consist in making the workman cease his work and in giving him a post where the dust is less abundant.

As regards the tumour itself, the prophylaxis is of the simplest. It consists in excising the warts before they undergo cancerous changes, or of removing the cancer as soon as it appears.

Regular medical supervision should be sufficient to prevent any appearance of cancer, and all the more easily as cancer from the by-products of coal progresses slowly and it is possible completely and definitely to extirpate it before the neighbouring neighbouring lymphatic glands are involved (see also article "Occupational Diseases: Urinary and Genital Tracts").

When the cancer has reached this first stage, it must be treated as any other cancer by free surgical removal, by penetrating X-rays or radium, and sometimes by the two methods combined.

2. Prophylaxis of cancer caused by radiations lies entirely in treatment of the pre-cancerous state: removal of the tumours; application of infra-red rays which have a special action on radic and radium dermatitis; and, if the disease is advanced, by necessary amputations. There should be noted particularly the remarkable effect of applications of radium on those warts which are of recent appearance due to X-rays and to radium, as well as on those in process of cancerous degeneration, and the excellent results obtained by Brodier by electro-coagulation.

As Teutschlaender points out (1930), the struggle against both external causes (carcinogenic substances) and internal causes (constitution) is extremely arduous and preventive measures should aim at diminishing contact with carcinogenic substances.

LEGISLATION

Epitheliomatous ulcerations and cancer of the skin are compulsorily notifiable in Germany, Great Britain, and Holland, in the industries of asphalt, briquettes, cyanisation, petroleum, textiles, chimney-sweeping, dyeing and X-ray work, and in France any sickness due to X-rays. In Russia, diseases of the bladder from analine are compulsorily notifiable. Compensation is granted in Germany for ulceration from soot, tar, pitch, paraffin and anthracene; in Western Australia for tar, pitch and mineral oils; in the United States (in Minnesota, Ohio and New York) from tar and pitch; in France, radiologists' cancer; in Great Britain (from tar, pitch, mineral oils); in Mexico (from paraffin, tar and similar substances); in Queensland (from tar and pitch); in the U.S.S.R. (from resin, soot, tar, paraffin, anthracene, radium and X-rays); in Venezuela (from tar, pitch, asphalt, mineral oils, petroleum, paraffin and all other derivatives of tar). Epitheliomatous ulcerations of chimneysweeps are also compensated in Great Britain, Western Australia and the U.S.S.R.; in Great Britain those occurr-
ring in cotton spinners. (See articles "Radium", and "Ronigen Ray Operators (Occupational Pathology of").

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See also:


The plates have been taken from original photographs kindly furnished by Professor Bayet.

Prof. A. Bayet (Brussels).

Tungsten


Tungsten or wolfram (symbol Tu or W) is a grey metal in a powdered state, which becomes brilliant white when molten. It melts at 3,000° C., and may be drawn out in a fine wire up to a diameter of 0.005 mm. The breaking load for traction is very high — up to 460 kg. per sq. mm.

So far tungsten has not been discovered in a free state. On the other hand, it is almost all parts of the world it exists in large quantities in combination with other ores, the most important of which are: wolframite (FeO[MnO] WO₃), a tungstate of iron and of manganese; scheelite (CaWO₄), a tungstate of calcium; hubnerite (Ca₂WO₄), a tungstate of manganese, with 72 to 77 per cent. of WO₄, which is; however, the least abundant mineral, etc. Tungsten is usually met with in tin, lead, molybdenum and copper ore, etc.

Of the various ores, wolframite is particularly abundant. The commercial product, after being subjected to bolting in the mine, is placed on the market in the form of concentrated ore.

After bolting and separation by magnet, the ores are enriched by mechanical and also frequently by electromagnetic treatment, and quartz is thereafter removed by means of levigating with water. The tungsten ore is obtained in a pure state if lime water is added during the above operations. Usually the ore is combined with soda to facilitate extraction of the tungstate acid (WO₄). The latter serves as the starting point for the preparation of the free metal by reducing the tungstate acid with powdered aluminium, in the presence of a flux, in the electric furnace.

It is not necessary here to enter into detail in regard to the other processes adopted for the preparation of tungsten. It suffices to recall that it is used in metallurgical work for the manufacture of tungsten steels, which are known for their resistance; their high breaking load for traction, their hardness and their elasticity, and it is further used in the metallic form in the incandescent lamp industry, tungsten filaments possessing a high ignition point and a low heating capacity. By reason of these qualities they have now supplanted almost all other metallic filaments.

The numerous compounds of tungsten are also of great importance in the colour industry, in pottery, in the manufacture of phosphotungstic acid, and as reagents in laboratory analyses, etc.

Starting with tungsten chloride, on which carbon monoxide and phenylmagnesium bromide has been made to act, it is possible to obtain, by means of a special method, tungsten-carbonyl in the form of colourless crystals. The nitric acid becomes immediately decomposed, setting free carbon monoxide (Mond).

The use of tungsten oxide in the manufacture of filaments for incandescent lamps is not without interest from the health aspect. In 1924, Karantasis studied experimentally the toxi-
city of tungsten and of sodium tungstate, both by way of the gastric system and by hypodermic administration. The guinea pigs used for the experiment suffered from anorexia, colic, lack of co-ordination in movement, trembling and dyspnoea. Tungsten was found in the stomach and intestines, the liver, the kidneys, the lungs, the blood and the urine. When administered hypodermically the guinea pigs also suffered from loss of weight. Tungsten was detected in the urine and faecal matter throughout the duration of the experiments on the animals which died after sixteen or seventeen days. It was likewise found in the lungs, blood, liver and kidneys, etc.

Tungsten salts act as slow poisons, and cause death by asphyxiation. Their toxicity is not high, but they may produce chronic intoxication by accumulation. (See also article "Molybdenum").

Though tungsten and its compounds are employed on a large scale both in laboratories and in industry, so far no case of occupational poisoning has been brought to notice, with the result that this product is not so far of great importance from the point of view of industrial hygiene. The estimation of quantities of tungsten below 0.1 grm. is a very delicate matter. The colorimetric determination is based on the colour assumed by tungsten dissolved in concentrated sulphuric acid in presence of phenols, hydroquinon and rhodamine.

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**Turpentine**


Turpentine is a resinous oil, that is to say, a product of exudation from coniferous trees, and particularly from the pine. It is also obtained from the turpentine tree (*Pistacia terebinthus* Linn.), which abounds in the isle of Chios (Chian turpentine).

All turpentines are of unnatural origin in the sense that they are extracted from trees by means of incisions, more or less deep, made into their trunks. The only natural turpentine — that which flows or transudes spontaneously from the tree — is the so-called Strasbourg turpentine, which is obtained from the *Abies pectinata* D.C. (*Pinus picea* L.).

Several varieties of turpentine are found in commerce, which are named according to their place of origin: Venetian turpentine, extracted from *Pinus larix* L.; French turpentine, also called Bordeaux or Landes turpentine, extracted from *Pinus pinaster* Solander or *Pinus thunbergiana* Poiret; American turpentine, from Canada or Boston, obtained from *Abies balsamea* Miller and from *Abies Fraseri* Lindl.; from Virginia, obtained from *Pinus taeda* Linn.; and Austrian or German turpentine from *Pinus larix* Poiret and from *Pinus Sylvestris* Linn.

Other varieties of turpentine are: Hungarian, Russian, Grecian, Finnish and Portuguese.

In commerce there are also a large number of synthetic turpentines or substitutes for turpentine, composed in large part of colophane, oil of resin and turpentine oil; the oil extracted from pine wood is added.

Turpentine is composed of a liquid part, called gemme, and a sticky part, called galipot or barras, which hardens rapidly and remains stuck to the edges of the incisions. The gemme, which is at first liquid and transparent, soon becomes thick and viscous on contact with air. During the process of collection, the galipot is almost always mixed with the gemme; the impurities are separated by melting in boilers and by clarification, decantation and filtration.

Fine turpentines — Venetian and those from Alsace and the Carpathians — are semi-fluid or viscous like honey, and slightly fluorescent; they have a yellowish or yellowish-green colour, a labilical aromatic agreeable odour, and a bitter, somewhat acrid, taste.

Ordinary French and American turpentines are, on the other hand, somewhat thick and granular; in time they form a micro-crystalline resinous deposit, and dry quite readily in the air.

Chemically, turpentines are made up of various resinous or resinic acids, among which pimaric acid (*C₃₆H₅₄O₃*) predominates, neutral resins, a volatile oil, small quantities of bitter principles, succinic acid, colouring matter, water and various impurities.

Turpentines are soluble wholly or partially, according to the quality, in ethylic alcohol, ether, amyl alcohol, chloroform, acetone, sulphide and tetrachloride of carbon and benzoil, and in turpentine oil in the proportion of 1 : 3.

Their direct use is limited. They are used generally in pharmacy for preparing plasters or ointments, either soothing or vesicatory, and in industries for preparing colours or sealing wax, and sometimes varnishes.

**Turpentine**

For the most part turpentines are, on the other hand, subjected to distillation to obtain a volatile or essential oil, *spirit of turpentine* and *colophane* or Grecian pitch, which remains as residue and becomes solid at the ordinary temperature. After standing a few days for the water to separate, the spirit of turpentine is rectified by a fresh distillation, in the presence of lime, with the object of refining the odour and getting rid of the fatty and resinous substances which it contains in solution.

**SPIRIT OF TURPENTINE**

Spirit of turpentine, which is also known in commerce under the name of Venetian, French or German turpentine, according to the source and quality of turpentine from which it comes, is a colourless, limpid liquid, sometimes yellowish or greenish, with a characteristic penetrating odour, and a burning, bitter taste. When exposed to air and light, spirits of turpentine absorbs oxygen, and so becomes oxonised or resinified; at the same time it condenses and turns yellow. With a density between 0.863 and 0.875, it boils between 155° and 180° C., but the largest part, 80 per cent., distils below 160° C. It ignites at 33-36° C. and burns with a yellow flame. For the most part turpentines are on the market in the form of spirits of turpentine, especially decaline, and are found in commerce as solutions.

Commercial spirit of turpentine is often adulterated by the addition of naphtha, oil of pine wood, light tar oils composed of benzene and its homologues, and of spirit or oil of resin.

The numerous substitutes which constitute industrial or synthetic spirit of turpentine are found in commerce (see article "Solvents") under fancy names have, for the most part, a basis of naphtha, light oils of tar, terpenes, oil of pine wood, oils of resin, and, particularly, a basis of decaline and tetraline.

In industry, spirit of turpentine is used to prepare terpine and terpinol, substitutes for camphor, and for adulterating numerous essential oils, particularly the essences of such acid fruits as oranges and lemons. But its chief use is based on its solvent and actively oxidising powers and on its volatility.

As spirit of turpentine is a good solvent for fats, resins, rubber, asphalt, bitumen, phenol and sulphur, it is used for cleaning textile fabrics, type and the rollers of printing machines, for decolorising ivory and dissolving rubber; but, chiefly, for preparing resin-varnish and as a drying oil for paints, for which it is practically indispensable, for it encourages the oxidation and drying of both. However, the solubility of resins in spirit of turpentine and of other substances used for the preparation of varnishes is not always the same. Spirit of turpentine reacts strongly, with great evolution of heat, with nitric acid, sulphuric acid and with iodine. In the first case there is a copious production of red nitrous fumes, in the second of sulphurous anhydride, and in the third of carbon, with a tendency to spontaneous combustion.

**STATISTICS**

Only one or two fatal cases from the inhalation of turpentine fumes are known. On the other hand, cases of dermatitis caused by this substance or its substitutes are very numerous.

E. Glaser mentions forty-six monographs, almost all by German authors, and A. Perutz in 1927 made a fresh contribution to the question. In Italy, Preti in 1911 described 4 cases of dermatitis in painters; Aiello in 1926 observed 15 cases in a metal factory; Filippini found 51 cases among 450 painters, 11.3 per cent., in the employment of the State Railways from July 1926 to March 1927.

In Switzerland, the National Accident Insurance Office has compensated 8 cases of dermatitis due to turpentine. Factory inspectors in Austria and Germany have reported several cases caused either by spirit of turpentine or by its substitutes in laboratories during galvanising; and by pine oil in laboratories during lacquering.

In Great Britain, turpentine and its substitutes caused 66 cases of dermatitis in 1928, 67 in 1929 and 49 in 1930.

**PATHOLOGY**

The cutaneous lesions caused by spirit of turpentine are polymorphous. They may be grouped as follows: an erythematous form, accompanied by a sensation of heat and itching, which resembles the erythema of scarlatina; a papulous form with itching; an urticarial form, which is not uncommon; a vesicular form, which is the commonest form of occupational dermatitis due to turpentine; and a vesicular form.

Local action of long duration, or often repeated, exerts an irritant and vesicatory effect which is well known, and leaves somewhat deep wounds which heal slowly. Generally speaking, substances used as substitutes for spirit of turpentine, especially decaline, tetraline and wood oil, cause a der-
matitis similar to that of spirit of turpentine, but more severe. On the other hand, mineral oils are quite well tolerated; but they have rather a tendency to cause acneiform dermatitis, which is clinically different from that caused by turpentine or by wood oil, or by the derivatives of naphthaline, decalone and tetraline (Filippini).

McCord in 1924 investigated 10 cases of dermatitis due to wood turpentine, and formed the opinion that these cases of dermatitis have no specific characteristics, the affections produced resembling those reported in dermatitis due to various chemical agents, such as naphtha and benzene.

Perutz in 1928 also described 15 cases of dermatitis, and concluded that the acute form presented an allergic character, a hereditary tendency to sensitisation encouraging the action of the irritant agent. The sub-acute form is a combination of specific cutaneous changes which result from the effect of the irritant; the chronic form appears as a chronic eczematous condition, independent of any allergic reaction. The disappearance of this last condition would appear to be due to the skin becoming accustomed to the injurious substance.

Gebert in 1913 attributed to impure turpentine a papulous and vesiculo-papulous eruption of the hands and forearms found among printers. Knowles in 1913 also observed 8 cases of this condition. Coleophane or "rosin" used alone or mixed with such other substances as mica, shellac or fat, or even glass-makers' grease, which is applied to the hands and the mould while melting glass, has also a very irritating action on the skin.

Stein in 1904 attributed to colophane dermatitis of the hands found among glass-blowers. Beinhauer found in a violinist a relapsing dermatitis of the second and third fingers of the left hand due to the use of colophane.

Casazza (1928), on the other hand, proved that cases of eczema among painters were due to turpentine rather than to substances used in the varnish (coleophane).

Concentrated spirit of turpentine causes an intense irritation on the mucous membranes; on the other hand, if it is diluted or in the form of vapours mixed with steam, it is tolerated quite well. Absorption takes place by the skin and the digestive and respiratory organs. But the effects vary considerably, according to the sensitiveness of the individual.

As regards toxicity, Lehmann found that spirit of turpentine in the strength of 3 to 4 mg. per litre of air caused in a cat sudden signs of strong irritation of the mucous membranes, especially of the eyes, and, after a few hours, slight convulsions. With 8 mg. per litre of air, after thirty to sixty minutes, it caused serious disorders of the sense of equilibrium and tetanic convulsions; and, after two and a half to three hours, paralysis. With 16 mg. per litre the animal died in from three-quarters of an hour to one hour. A strength of 4 to 6 mg. caused in a man after one hour a pricking sensation in the eyes, cephalalgia, vertigo, nausea and an acceleration of the pulse.

Daily paintings with spirit of turpentine caused serious dermatitis in a dog (Lehmann).

Some animals exposed to the inhalation of turpentine vapours exhibited such signs of malaise as salivation, a tendency to diarrhoea, and strabismus, in less than two hours after, when the strength of the spirit of turpentine did not exceed 10 mg. per litre of air (Goadby). At the autopsy, inflammatory lesions of the kidneys were found, which were more marked in the tubular elements than in the interstitial. The tubes, blocked by detritus, showed an irregular and eroded contour, and a pale and almost hyalin appearance; there were, in places, zones of swelling, thick with small haemorrhages. Cardiac muscle was flaccid, and the cavities were dilated; capillary haemorrhages were seen with the microscope.

The acute form of poisoning by the digestive organs has no interest from the point of view of industrial medicine. On the other hand, that caused by the inhalation of fumes of spirit of turpentine must be taken into consideration.

Painters, as well as persons who have slept in places freshly painted, are particularly exposed to this kind of poisoning, which has been described by Bouchardat. But these cases are slight and of short duration. G. Porrini in 1908 observed symptoms of somewhat serious poisoning due to spirit of turpentine in 27 out of 89 ship-painters he examined who worked ashore, and in 106 out of 145 who worked on board ship. These 145 painters comprised 91.17 per cent. of those who worked in closed places (cabins and corridors of ships), 69.56 of those who were employed on board and 57.89 of all the painters in the shipyards.

Alcoholics and neurpaths are unusually sensitive to spirit of turpentine.
After working for half an hour to an hour workers suffer from irritation of the oculcar and nasal mucous membranes and of the throat; headaches, mental confusion, and a state of excitement, resembling drunkenness. If the inhalation of the fumes does not cease, there may follow a state of anxiety, accompanied by buzzing in the head, visual disturbances and vertigo, which end in the sufferer falling to the ground.

In a polish-making factory four women workers complained of pains in the stomach, nausea and a feeling of constriction in the throat. One of them fainted and developed oedema of the glottis which required tracheotomy (Adler Herzmark). A fatal case has been reported in a worker who applied varnish (A. Drescher); but it seems that this is the only fatal case recorded.

Working painters have also reported a hot bitter sensation in the pharynx, lack of appetite, weakness or fatigue, a general feeling of heat and sometimes profuse sweats, with the breath smelling of the spirit, and a burning thirst. The pulse is hard and frequent; there is slight strangury; the urine is red and has an odour of violets.

In two cases described by McCorkle in 1930 there was nephritis characterised by a diminution in the quantity of urine and by albuminuria.

Goaebby, after investigation of the renal lesions, has deduced that the pathogenic action of spirit of turpentine, as inhaled by painters, is to increase that of lead. Lehmann has also expressed the opinion that turpentine has a definite influence on the diseases of the kidneys.

From the clinical and anatomo-pathological point of view, the two most important and durable manifestations caused by turpentine on the body seem to be hypertension and tubular nephritis, which after a time succeed vasomotor disturbances. It is a matter for discussion as to whether the first can be regarded as the cause of the second, or whether the two conditions occur independently. But the discussion is only of theoretical value. On the other hand, it is of great practical importance to fix what part lead plays in the origin of the condition or in the diseases of painters, and what is the part played by spirit of turpentine.

An opinion in favour of the pathological influence of the latter predominating over the former was put forward by Leclaire as long ago as 1861, in a communication presented to the Paris Academy of Science, but was forgotten; but the opinion was taken up again and maintained by Goaebby and others during the discussion on the prohibition of the use of white lead in painting at the Third International Labour Conference, Geneva, 1921. If the matter is considered from the point of view of the nature of the pathological manifestations caused by spirit of turpentine, the conclusion seems justified that they are indeed certainly less serious and present a clinical and anatomical aspect quite different from that found in lead poisoning (Loriga). It is in fact not possible to attribute to turpentine the majority of the morbid conditions hitherto attributed to lead. In addition to the reserves that must be made as to the frequency of their appearance in working painters, Loriga rightly emphasised at the above-mentioned Conference that "every practising doctor is able to make, with very great accuracy, a differential diagnosis between renal irritation due to turpentine — a slight and not serious illness — and true Bright's disease — a chronic and incurable disease caused by lead; and that every doctor is easily able to distinguish between the acute and occasional headache arising from simple vaso-motor disorders, caused by turpentine, and the same symptoms, when resulting from saturnine cephalopathic lesions; and that no experienced doctor can mistake abdominal pains, followed almost always by diarrhoea when caused by turpentine, for true dry lead colic".

In the cleaning of printing-machine rollers it has been proposed to replace spirit of turpentine by Borneo benzene which is considered less irritating for the mucous membranes. This oil evaporates slightly more rapidly than the spirit of turpentine, but its repeated action may cause serious and even fatal troubles. A premonitory symptom is, for instance, gingivitis. As soon as this appears, an examination should be made of the blood, the characteristic lesion of which is leukaemia with myelocitls (particularly with eosinophilia accompanied by punctate basophilia). This clinical picture corresponds to that of Naegeli myelosis (A. Brandt).

**Detection**

A colorimetric method of estimating the strength of fumes of spirit of turpentine in air was proposed by Rogatzky and Biber: mix 30 litres of the air in 50 cub. cm. of alcohol at 96°; take a sample of 5 cub. cm. of the solution so obtained and add to it an equal volume of a 1 per cent. solution of vanilla in concentrated hydrochloric acid; mix and compare the colour.
obtained at the end of a quarter of an hour with that of standard solutions. This method was tested by Koreman in 1930; he found that it entirely lacked exactness.

A colorimetric method proposed by Andreev and Gavrilov (1929) is based on the property of turpentine to colour sulphuric acid; the coloration is appreciable for a strength of less than one in a million.

HYGIENE

The resin oil industry has two principal inconveniences, the resinous odour and danger of fire.

Governments require that factories should be constructed of non-inflammable materials; that workplaces must be well ventilated; and that the floor should be impermeable. They prohibit lighting with lamps which have a naked flame and require lighting to be by daylight or by lamps placed outside and protected by glass in a fixed frame. The furnace openings must be external to the workplaces; the distilling apparatus must be separated by a wall from the condensation apparatus; the gases which are not condensed are to be directed under the bars of the furnaces, so that they are burnt; a very high chimney must be provided for the factory. The workplaces must be isolated and at a distance from the warehouses for storing raw materials and manufactured products. Loose sand should be provided, and measures taken against fire.

Prophylactic measures to be taken against dangers from turpentine must vary according to whether it is a case of protecting the skin against contact with the liquid, or the respiratory organs or the eyes.

The recommendation to avoid using turpentine as a solvent of fats, and for cleaning clothes, ivory, or rollers and type used in printing should be readily accepted, since turpentine can be replaced by other solvents which are more active and less costly, such as petrol spirit, benzene, or carbon bisulphide; but no advantage would accrue from the health point of view, since the fumes from these solvents are much more injurious to health than those of turpentine. The paint and varnish industry cannot dispense with varnish, which is used as a solvent of resins, as a diluent and expedient of other ingredients, as a means favouring the oxidation of varnish, and as a corrector of too rapid drying; so it is necessary to provide the means calculated to prevent the injuries referred to above. It has been noted that the affections from which painters suffer occur exclusively, or almost exclusively, during work done in closed places, which are small and badly ventilated, especially when the temperature is high, as in cabins of ships. For prophylaxis, it is necessary that the ventilation of these places be kept active, and of the volume of air. As regards stain-removing operations, they can in some cases be carried out in closed vats; but even so, adequate ventilation of the place must be maintained.

Protection of the skin of the hands and forearms cannot be obtained by wearing rubber gloves, as they do not resist the action of turpentine. Gloves of other materials become impregnated and adherent to the skin, aggravating the condition instead of improving it. Smearing the hands and forearms with linseed, or vaseline may be recommended, or, better still, with a mixture of olive oil and beeswax. The use of detergents for removing turpentine or varnish on leaving work must be avoided. These detergents irritate the skin and aggravate the action of the turpentine. The use of sand, chalk, and alkali soaps which dissolve the fat from the skin, and attack the chitin, which is the cement of the cells of the corneal layer of the epidermis, must be avoided. Crude linseed oil should be used as a deterrent, and sawdust, for mechanically aiding the cleansing, should be provided for workers.

The working clothes must be kept clean, especially the sleeves and neck. Persons showing special sensibility to turpentine must be excluded from work; and also those who show cutaneous lesions or who are affected by seborrhoea, hyperhydrosis, prurigo or who have anaemic skin. Filippini advises testing the cutaneous sensibility of workers before admission to work, by applying for twenty-four hours on the skin of the arm or chest a little square of linen impregnated with the substance under consideration, whether turpentine, substitute, or varnish already prepared, and covered with a larger square of jackinette. In the normal person, there is no reaction, or at most a superficial erythema. Sensitive persons show a reaction, infiltrating erythematous, vesicular and papulo-serous eruptions; after only a few hours, these persons experience a sensation of burning and itching to such a degree that they are obliged to remove the irritating substance.

LEGISLATION

Women and children are protected by Orders in many countries which regulate...
Type is made from a special alloy, the composition of which is generally as follows: lead, 60 to 75 per cent.; antimony, 30 to 23 per cent.; tin, 10 to 2 per cent. It should, however, be noted that as a rule a distinction is made between two different alloys according to their content of lead: a black alloy, hard and brittle, made of lead, tin, and about 40 per cent. antimony, and a white alloy, made almost entirely of lead and used for interlines, clumps, quadrats, and spaces which have to bend readily without breaking under the pressure of the machines. For printing large advertising placards in relief, bronze type is used (a German special line).

**INDUSTRIAL PROCESSES**

The manufacture of printing type necessitates the use of dies and matrices into which the melted metal forming the letters is poured.

The cutting of the dies in steel, which used to be done by a highly skilled workman, is now done by perfectly accurate engraving machines, which are really exceedingly delicate pantographs. But this technique necessitates very carefully prepared designs for reproduction.

A small block bearing the letter in relief is passed on to the engravers for finishing, and the removal of mould marks. The cut letters, retouched and cleaned, are then passed into a nickel-plating bath, from which, after about forty-eight hours, they emerge covered with a thick layer of nickel which reproduces the design of the letters. These matrices, mounted on a metal stand, are passed on to rectangular men who set them square and rectify the depth of the face. The matrix is then ready for starting type casting.

The alloy is melted in open crucibles in Belgium and France, or in closed crucibles in Germany, Great Britain and Italy. Some factories have adopted electric heating for the crucibles. First, some lead is melted, then the antimony is added and the remainder of the lead; finally, the tin is added, and, as required, any other metals which the alloy is to contain.

One workman attends to the fire and refines the melted metal by removing with a ladle the scum which rises to the surface of the molten metal. By means of analyses and the addition of metals not present in sufficient amount, the composition of the alloy can easily be kept accurate.

The casting of the type is sometimes done by hand, for the preparation of large type, rules, interlinings, quadrats, and clumps; but it is more often done by machinery.

In the manual foundries, the letters are cast one by one in a mould, the workmen pouring the molten alloy by means of a ladle. When the mould opens, the metal liquefies and is then extracted, and the mould again, when the process is repeated. When he is making clumps and quadrats, or when he wants to obtain long lines, he hastens the solidification of the metal by rapid contact with a moistened rag.

By solidifying the metal in this way he stops the flow into the feeding channel.
In casting by machinery, a pump throws a jet of molten metal into a melting pot which adjoins the machine, into a mould which is in two parts and opens to allow the letter which has been cast to fall out. Sometimes it is a case of a matrix being fixed in a mould, movable in a slide, into which a jet of molten metal is injected.

Remnants or "masselottes" of molten metal adhere to the type thus formed. By striking each letter on a metal table a sharp blow, these remnants are broken off at the level of the foot of the letter. Type, cast by hand or by machinery, is next subjected to the finishing processes — shaping, dressing and calibrating, by means of magnifying glasses. Type in which the stem is diagonal, or projects beyond the thickness of the letter, is subjected to special fraising under the portions which extend beyond the body of the letter — a long and tedious operation.

Type used in different countries differs in height, so the letters are placed on long composing-sticks and passed to shortening-machines which cut them down by means of special milling.

Machines are often used which do all these operations automatically and reduce contact with the alloy to a minimum.

After classification, packing follows.

Men are almost exclusively employed at the melting crucibles; all the other operations of sorting, polishing and packing the letters, women are employed by preference, as has been reported by A. Hamilton in 1916, in the type foundries of the United States.

In the department of wood engraving small blocks of wood are prepared of the size required for the work of the type foundry. Dust is removed by suction and adequately withdrawn so as to fulfil the requirements of hygiene.

Stereotyping plays a very important part in the printing of newspapers. Stereotyped plates, prepared in single pieces, reproduce a page of composition ready for printing, obtained by assembling movable blocks. The plate makes it possible for successive editions to be printed conforming to the first without disturbing the type of the blocks. Its use is essential for printing on rotary machines. Plates are prepared by moulding, i.e. by taking an imprint of the composition by means of a sheet of special papier-maché, or by superimposed leaves of paper, between which is spread a paste mixed with Spanish white. Into this mould, dried flat for an ordinary plate, or on the curve for a rotary plate, the melted type alloy is run, and so forms the actual stereotyped plates which are used for printing. (As regards plates used in electroplating and "electrotyping," see articles "Photo Engravers" and "Electrotyping."). After moulding, the edges and seams of each plate are pared; and the plates are adjusted and corrected.

**Sources of Danger**

There will now be enumerated the chief sources of danger during the various operations of preparing the type metal, and casting and finishing the letters:

1. **Metallic dust of lead and antimony.** Some of these dusts are light and easily absorbed by the respiratory and digestive organs; others are heavy, and danger results from rubbing against the metal, which adheres to the skin.

There is considerable danger from dust generated during the removal of the oxidation scum where the founders adopt the deplorable habit of dropping it on the floor. Metallic dust may also arise from splashing from the machines. Thiele has drawn attention to the projection of molten metal on to the floor. Microscopical analysis of the dust has shown that lead occurs in the form of fine dust of a dark colour, and also as larger particles, with a metallic lustre, varying in shape.

Heavy dust comes chiefly from the operations of scraping and polishing. Its greasiness makes it adhere to the skin, whence it can only be removed with difficulty by washing. Its direct absorption is doubted; if it occurs, it may be facilitated by abrasions or by thinness of the skin.

Seitz has collected from the hands of a number of typefounders, even after the hands had been washed, quantities of lead weighing more than 7 mg., and more than 8 mg. in the case of women polishers, and also minute quantities of antimony.

By analysing samples of dust collected in the workshops and even from tables reserved for meals, the same authority found appreciable quantities of lead and antimony as the following figures show:

<table>
<thead>
<tr>
<th>Source</th>
<th>Total dust</th>
<th>Lead</th>
<th>Antimony</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table cleaned for dinner</td>
<td>76</td>
<td>3.2</td>
<td>—</td>
</tr>
<tr>
<td>Shelves placed 1.50 m.</td>
<td>13</td>
<td>7.3</td>
<td>1.4</td>
</tr>
<tr>
<td>from the floor</td>
<td>18</td>
<td>6</td>
<td>1.2</td>
</tr>
</tbody>
</table>

**Typefounders**
Further, workers carry dust on their clothing; they eat it, drink it, and smoke it. This explains why, although the quantity of lead manipulated is much less than in the lead foundries, the danger of lead poisoning is not less acute; moreover, the work is at times carried out in small, unhealthy, badly ventilated workshops, annexes to the printing works, where the atmosphere is easily loaded with unhealthy products which are not removed quickly enough.

During an enquiry made in the United States, A. Hamilton found that the absorption of dust is often facilitated by the fact that the work of finishing requires such close attention that the women who are employed work with the head bent close over the work. The dust covering the svork benches is especially thick as the finishing process is often effected in the same workshop as the type-casting department.

Considerable quantities of lead have of course been found in dust from hoods and ventilating shafts, and from window fittings. The Public Health Authority for Saxony collected 34 samples of dust from 29 works and found in them as much as 22.5 per cent. of lead. Even so, in foundries having as many as 20, 30 and even 50 melting places, but where the spacing, ventilation and cleanliness were adequate, there was very little danger. In a foundry having 58 melting pots without exhaust ventilation, a foundry which, about four weeks before the samples were taken, had been whitewashed, only 0.17 per cent. of lead was found in the dust. This danger may be greater in stereotyping, where there is considerable liberation of dust, especially when the casting is done by hand. It should be remembered that this danger is not always in proportion to the number of melting pots.

Thus, in a foundry with a single pot and a cubic space of 144 metres, the dust was found to contain 4.7, 6.7 and 11.6 per cent. of lead. In a foundry set up in a cellar, 12.6 per cent. of lead was found, whilst in the stereotyping room of the same works, situated high and well ventilated, the proportion of lead was only 0.7 and 2.6 per cent. Actual appearances are not sufficient for judging the relative cleanliness. Some works, regarded as healthy by factory inspectors, have given contents of lead as high as 7.81, 8.88, 11.45, and 13.66 per cent.; others, where the workshops had been whitewashed and where the rules laid down for cleanliness were observed, only gave lead contents of 0.85, 0.68 and 0.51 per cent.

2. Metallic fumes of lead, antimony, or arsenic. Fumes are produced when type alloy and old type are heated to melting point over an open fire. This question of the giving off of fumes is, as is well known, somewhat controversial.

According to some experts, including Silberstein and Seltz, metallic fumes cannot be given off, for the temperature of the alloy, varying between 500° and 520° C., is always lower than the temperature at which lead volatilises, 1,525° C. According to Lewin, however, this limit is lowered when lead contains impurities, or is alloyed with other metals, such as tin. Frois and Gerin found that fumes given off from the molten alloy are free from lead. Seltz, at all events, could not detect, by testing with yellow sulphide of ammonium, lead fumes in melting shops, even when the melting pots were heated to such high temperatures as 508° C. In tests made in the laboratory, however, with pots the temperature of which varied between 423° C. and 588° C., he detected in a first test 0.2 mg. of lead and in others 0.35 mg.

An enquiry made in the Government Printing Works at Berlin enabled Heise to form the opinion that, when the technique is adequate, there is no liberation of lead in the state of fumes from above the melting pots.

Roth, on analysing the air of type foundries, did not find lead fumes in 10 litres of air drawn from the surface of melted metal at a temperature of 550° C. The presence of lead fumes was only observed at a temperature above 650° C.

Another test made by an engineer of the name of Fischler shows the following results:

<table>
<thead>
<tr>
<th>Grammes per 100 litres of air</th>
<th>Lead</th>
<th>Antimony</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Kunstmann system of melting machine (over 450° C.)</td>
<td>negative</td>
<td>negative</td>
</tr>
<tr>
<td>Melting furnace in the foundry (over 470° C.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melting furnace in the stereotyping department (over 500° C.)</td>
<td>0.0025 to 0.0016</td>
<td>0.0016 to 0.0005</td>
</tr>
</tbody>
</table>

It may thus be concluded that the evolution of fumes is associated with temperatures over 500° C. and need only be considered in connection with the few melting pots which require a particularly high temperature.
Insufficient supervision of the furnaces may, however, cause fumes to be given off. As a matter of fact, variations in the temperature of the pots are not estimated by such accurate instruments as pyrometers, but by the workmen, who rely on their working experience; hence arises the possibility of errors in appreciation, especially when comparatively old workmen are concerned, whose senses may be somewhat dulled.

At Leipzig, for instance, in a large type foundry, 18 per cent. of the workmen were between fifty and sixty years and 25 per cent. between sixty and seventy. So there is an absence of any accurate regulation of the temperature at the surface of the molten metal; and the sources of heat are not regulated as they ought to be. Seitz was able, on the same morning, with the same founder, to observe the following temperatures in an alloy bath: 556° C., 517° C., 533° C., and 519° C. He several times noticed differences in temperature of 30° and 40°. In this way temperatures may be reached which are sufficiently high for the partial volatilisation of lead.

Thiele, on the contrary, denies the statements of Seitz that danger from lead fumes is slight in type foundries. He does not believe that the exhaust hoods placed over the melting pots provide a good means of protection.

Further, even if there is but slight evolution of lead fumes, it must not be overlooked that the risk is continuous, that the small quantities accumulate, and that the founder is undoubtedly exposed to risk not merely when he leans over the surface of the metal to remove the oxidised scum, but similarly when charging the crucibles with unmelted metal.

The fact that antimony may contain arsenic as an impurity must not be overlooked.

3. Organic fumes. These arise in general from grease and dirt from the colours and inks which adhere to the lead scrap, to the type and used interlines, and come off, as acrolein, etc., during melting.

4. Heat and comparative humidity constitute two factors which are prejudicial to the health of the workers. In one foundry the cubic air space was 23 m. per person, the temperature 34.9° C. and the relative humidity 72 per cent.; in another the cubic air space was 15 m., the temperature 27° C. and the humidity 50 per cent. (Seitz).

At Vienna temperatures of 35° and 40° C. were noticed and at Berlin of 30° C. (Sommerfeld).

Some firms, including the Turin firm Nebiolo, have completely done away with gas for heating the melting pots on the casting machines, and have replaced it by electric heating which ensures the uniform temperature desired for melting the metal in the pot and eliminates all the inconveniences of gas, such as the radiation of heat. In this way the workshops are rendered perfectly healthy.

Cleaners of old type, before passing it on to be melted, may be exposed to the poisonous influence of the various solvents used, such as benzine and methyl alcohol (see those articles).

Among accidents may be noted burns, from splashings of molten metal, on the hands, arms, chest and face, occasionally on the feet, and more rarely the eyes.

**Statistics**

According to the statistics of Grotjahn dealing with 200,000 persons employed in the German printing industry (1907), 15,000 were founders and type engravers.

The statistics of the sickness offices show that the occupation of typefounder is among the most dangerous of the graphic arts. The percentage of incapacity for work among 1,044 typefounders of Leipzig, of whom 318 were women, in 1923 was 10.6 for men and 27.3 for women, whereas in 1914 out of a total of 516 workers, 159 of whom were women, the percentage of incapacity was 2.1 for men, and 28.9 for women.

During the period which elapsed from 1 January 1922 to 30 June 1923, the sickness offices counted 326 members who were typefounders, among whom were 53 cases of sickness (16.2 per cent, of all cases); 317 stereotypers and type engravers had 108 cases (34.1 per cent). The longest duration of service was found among stereotypers and typefounders, 22.2 per cent. of whom had worked more than 40 years.

As regards the number of days of sickness the following figures are given per 100 members:

<table>
<thead>
<tr>
<th>Year 1914</th>
<th>Number of sick</th>
<th>Number of days of sickness</th>
<th>Days of sickness per worker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polishers (women)</td>
<td>13</td>
<td>1,092</td>
<td>84.0</td>
</tr>
<tr>
<td>Type-casters</td>
<td>50</td>
<td>3,400</td>
<td>68.0</td>
</tr>
<tr>
<td>Type-melters</td>
<td>4</td>
<td>101</td>
<td>25.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year 1913</th>
<th>Number of sick</th>
<th>Number of days of sickness</th>
<th>Days of sickness per worker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polishers (women)</td>
<td>19</td>
<td>1,427</td>
<td>75.3</td>
</tr>
<tr>
<td>Type-casters</td>
<td>46</td>
<td>7,786</td>
<td>60.5</td>
</tr>
<tr>
<td>Type-melters</td>
<td>3</td>
<td>126</td>
<td>42.0</td>
</tr>
</tbody>
</table>
A large proportion of poisonings and especially of lead poisoning, without taking into account a high sickness rate from tuberculosis and from rheumatic pains, has been met with.

According to Seitz the various causes of sickness for 1922 can be classified according to occupational groups as follows:

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Typefounders</th>
<th>Stereotypers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaemia; diseases of the blood</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Diseases of the kidneys</td>
<td>---</td>
<td>1</td>
</tr>
<tr>
<td>Lead poisoning; gastric and intestinal colic</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Pulmonary diseases and pleurisy</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>Catarrh of the bronchi, asthma</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Heart diseases</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Furunculosis</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Rheumatism, sciatica, lumbago</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Grippe, influenza</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td>Diseases of the kidneys (from lead)</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Diseases of the skin and generative organs</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

In Germany an examination of typefounders gave, from 1910 to 1922, 21.1 per cent. of positive cases of lead absorption and amongst polishers 50 per cent. According to the statistics of the Leipzig office (1911) there were 3.4 per cent. of cases of lead absorption among typefounders compared with 1.90 in other categories of the printing trade (Seitz).

Examination of the blood, carried out during the period 1913-1922, in a German factory, employing on an average 228 workers, showed a percentage of 5.2 cases of lead absorption. In another firm with sixty workers, examination of the blood showed 1.6 per cent. Most of the positive results related to women polishers (42.8 per cent.); next came the typefounders with 26 per cent.; the other branches of the industry showed much lower figures. During the year 1923, the following were the percentages: typefounders (metal pour-

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<table>
<thead>
<tr>
<th>Occupations</th>
<th>Number of persons examined</th>
<th>Blue line</th>
<th>Punctate erythrocytes over 100 per million</th>
<th>Increase of porphyrin in the urine</th>
<th>Eosinophilia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stereotypers</td>
<td>33</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>Not examined</td>
</tr>
<tr>
<td>Typefounders</td>
<td>54</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>---</td>
</tr>
<tr>
<td>Women assisting in the foundries</td>
<td>37</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Apprentice founders</td>
<td>13</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>---</td>
</tr>
<tr>
<td>Lead melters</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Not examined</td>
</tr>
</tbody>
</table>

1 A slight increase of porphyrin found in one case was not detected on a second examination.

2 One of whom had a slight increase of porphyrin.

The typical lead colour was not found in any case.

According to figures of the sickness office for the printing trade in Vienna, 241 stereotype founders and 74 workers in typefoundries showed, during the period 1901-1908, the following average rates of sickness per 100 workers:

---

**Fig. 150.** — The engraving tool (firm of Nebiolo, Turin.)
The only cases of lead poisoning met with by the Commission of industrial diseases of Illinois among women employed in the printing industry related to women employed in founding type: 4 women employed in finishing type by hand and having a length of service varying from three years to thirty-five years suffered from chronic lead poisoning (Hamilton).

In France the statistics given by Orliac show 1.80 to 9.50 per cent. of lead poisoning among the founders; but these figures only concern the acute cases. Typefounders treated in the hospitals of Paris for lead poisoning during the period 1899-1901 numbered 41, with an average of ten days in hospital, and, during the period 1902-1905, 76 with twelve days in hospital (Orliac). In other countries the statistics relating to typefounders are given with those of printers (see article "Printing Trade").

One of the first studies on the hygienic and sanitary conditions of typefounders is that of E. Bertarelli (1903) which was made in an Italian factory at Turin. It extended over two years and dealt with the sanitary conditions of workmen and the hygiene of workplaces, including the presence of carbon monoxide and of lead fumes in the atmosphere.

The alloy used by the factory contained 55 parts of lead, 35 of antimony and 10 of tin: it melted at about 450° C. The work of melting was done mechanically and the temperature only rarely went beyond 500° C. Generally, only large type required to be trimmed with the file, and this process was done by women by hand.

The statistics were not proved to be absolutely accurate. Typefounders to the number of 131 were distributed in age-groups as follows: 15-30 years, 55; 31-50, 66; over 50, 10. The 50 women employed in work on type were distributed as follows: 15-30 years, 37; 31-50, 13.

Of the 131 men, 73 were employed in melting, 44 in cleaning and trimming, 10 in the warehouse and on additional work, and 4 at type cutting.

According to the works doctor, about 40 per cent. of the founders suffered from gastritis, sometimes troublesome; 25 per cent. from stomatitis; 30 from arteriosclerosis; 10 to 15 from nervous and muscular affections. During twelve months only one case of lead colic and one serious case of gastritis was reported. Tuberculosis was rare.

Nevertheless, Bertarelli admits a certain frequency of cases of gastritis, stomatitis and slight albuminuria, which he attributes to the effect of lead. Examination for lead in the urine of 12 founders and 10 women workers was negative; but about 30 per cent. of the women, who had worked in the factory for five years and over, showed signs of lead absorption.

The workers were exposed to the effect of rather high temperatures; but only rarely were traces of carbon monoxide detected in the air of the foundry. The measures adopted by the management did not eliminate the injurious effect of the lead, especially in the case of the workers in the trimming department. For this reason the author classes (1903) the industry as an unhealthy one, offering dangers to the health of the workers, dangers which are inevitably associated with the nature of the industrial operations.

Although recommending the management to improve the ventilation in the vicinity of the machines for melting type, to install exhaust ventilation for poisonous dust and to provide such means of personal cleanliness as baths and douches for the workers, the author was not able to prove the presence of lead in the state of fume in air taken at 50 cm. from the furnace, and could only find very slight traces of lead in the form of dust.

**PATHOLOGY**

Lead poisoning holds the first place. While, as Orliac says, acute conditions are somewhat rare, stealthy impregnation of the organs, on the contrary, appears to be the rule. This shows itself sometimes by serious attacks and sometimes by giving rise to slight illnesses, which the least cause, whether due to exhaustion, to fatigue, or to drink, aggravates.

The article "Lead, Poisoning by", records the frequency of pallor and anaemia. In the case of an apprentice founder whose symptoms seemed to indicate slight lead colic, Schwarz detected the existence of 2,000 erythrocytes with basophilic granules per million, traces of albuminuria and an increase of porphyrin in the urine. In the same
way an enquiry at Frankfort recorded pallor and subjective signs of lead poisoning in 13 apprentices examined, and in 7 an increase of eosinophilic leucocytes. Schrumpf and Zabel only rarely noticed in apprentices definite signs of lead poisoning; but, on the contrary, they found in several cases a clinical picture consisting in a tired facial expression, nervousness, irritability, fatigue, insomnia, vertigo, headaches, muscular pains, nausea, anorexia, intestinal disorders and constipation. Examination of the blood showed a diminution of leucocytes, with a comparative increase of eosinophilia, according to Seitz, examination of more than 90 founders and of the rest of the personnel of typefoundries did not reveal the presence of basophilic granules, although the personnel was exposed to a risk of lead poisoning. On the contrary, a relative lymphocytosis with diminution in the number of thrombocytes seems to be characteristic of the blood of founders. During an enquiry carried out at Frankfort, Schwarz found in 33 subjects indications of Schmidt's basophilia as follows: compositors, 19; typefounders, 4; stereotypers, 2; printers, 3; foremen, 1; proof readers, 2; printing machine minders, 2.

The answers elicited by Seitz disclosed, among other symptoms: cephalalgia, especially frontal, in 65 women, and in 62 men; vertigo in 8 women and 10 men; malaise, loss of appetite, and disorders of the stomach in 13 men and 15 women. Tuberculosis was found to be as common among typefounders as among printers. In 1919 Ranelletti reported that the incidence of lead poisoning amongst typefounders in Rome was twice as frequent as that met with amongst compositors, and eight times that noted amongst printers.
Mauro (1929) also has reported that lead poisoning amongst typefounders in Milan attained an incidence of 30 per cent. of the general morbidity. Whilst the typical symptoms of sub-acute lead poisoning are very rare, forms of arterio-sclerosis especially among young workers are very frequent. Mauro explains this by the penetration of lead into the system, and by time spent in overheated workrooms, causes which lead to injury of the heart and blood vessels favouring the development of changes of a toxic origin. (See article "Printing Trade").

**HYGIENE**

First and foremost the provision of machines and apparatus must be adequate and must be erected according to the latest ideas of modern technique. In addition a sufficient air space must be adopted for the workplaces (an instruction of the Swiss Inspectorate lays down 13 cu. m. per worker) as well as good general ventilation. The floors must be solid and smooth, varnished or polished or else tiled, so that they can be easily washed and the dust removed. Arrangements must be made for washing and whitewashing the walls. Desks and shelves must be placed in immediate contact with the floor, or sufficiently high for the floor to be easily cleaned. Daily cleaning of the floor and furniture, generally by the damp process, should be compulsory. No sweeping should be done before work is started, or during the meal interval. Complete change of air should be effected morning and evening. Most of these measures are laid down in Switzerland.

Melting pots, supplied with exhaust ventilation to remove fumes and dust, should be properly installed and maintained. The temperature should be accurately controlled.

**Fig. 191. — Casting machine-room (firm of Nebiolo, Turin).**

An important technical advance is represented by heating the pots electrically.

The preparation of the metallic alloy and the removal of dross should be done outside the workshops.

It is obviously desirable for the lead in the alloy to be replaced by something else, but, in view of the technical impossibility, it would perhaps be advisable to limit its use to ordinary type, by substituting blocks of iron or hard wood for the clumps of lead which keep the pages in position.

These general measures should be completed by strict enforcement of measures of personal cleanliness; lavatories and separate towels; washing
before meals; wearing of special overalls; protection of food against dust.

Spitting on the floors and smoking in the workshops should be prohibited.

Medical supervision of the personnel should also be established. Some experts think that it would be sufficient to limit this supervision to apprentices (Schwarz) and that it can be based on an examination of the blood and urine carried out on commencing work, and thereafter every three months.

LEGISLATION

See article "Printing Trade".

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***
Ultramarine


Ultramarine was obtained in the past by pulverisation of natural lapus lazuli, but since its exact chemical composition has become known and likewise means for preparing it artificially (Guimet, 1826) it is produced in accordance with two alternative processes:

(a) Calcination of a mixture of kaolin (30.5 per cent.), of sodium carbonate of sulphate (27 per cent.), of sulphur (31.5 per cent.) and of charcoal previously pulverised (4 per cent.); washing in water of the product obtained which constitutes azure ultramarine;

(b) Calcination of kaolin, sulphur and carbonate of soda, with exclusion of air, in crucibles placed in a furnace. This operation liberates sulphur dioxide, carbonic acid and sulphuretted hydrogen.

Ultramarine is at present used as a substitute for cobalt colours in the colouring materials industry.

Ultramarine colours may be classified as follows: inorganic colours, derived from borium, selenium and tellurium, which are true ultramarines; organic colours, organosols of varying composition which may be utilised as organic sulphur colouring agents; organo-mineral colours, hydrocarburetted ultramarine (ethyl or butyl ultramarine); temporary inorganic colours (isolated borium phosphates and ultramarine); and temporary organic colours (cyanuretted ultramarines).

Ultramarine colouring withstands even the presence of dissolvents or products which disintegrate sulphur compounds (cyanides, sulphur dioxides). The composition of ultramarine may therefore vary within wide limits.

Dust given off during crushing and pulverisation of the products utilised for the manufacture of ultramarine may prove dangerous since they contain silica. Ultramarine dust is neither hard nor irritant, but its colouring capacity is at times inconvenient. Gases given off during calcination (sulphur dioxide, sulphuric acid) may injure the health of workers engaged near the furnaces, whenever ventilation is defective.

Modern literature contains no mention of specific injuries occurring amongst workers in ultramarine factories. Nevertheless, there has been noted during autopsy the presence of large quantities of alumina in the lungs of these workers, side by side with silicotic, siderotic or chalciotic foci (Ultramarinlungen). The sputum had a greenish blue colour. The autopsy generally proved that the injuries were slight and localisation was restricted to the bronchial tubes.

Ultramarine factories should be constructed far from inhabited areas. The flooring of these factories should be impermeable and should have grooves to facilitate the running off of liquids. Furnaces should be so constructed that gases and fumes liberated may be neutralised and condensed. Only those products of manufacture which cannot be directly condensed should be evacuated by very high chimneys. Extremely effective ventilation should be provided.

Grinding and bolting of materials used should be effected in hermetically sealed apparatus in special workrooms designed for the purpose. Noisy machinery (mills) should be appropriately isolated from other departments. Waste waters should be decanted in special vats before being evacuated by way of the drainage system. Purification of these requires to be effected with care; deposits left should be removed and evacuated fairly frequently. Solid residues should never be thrown on to public highways or into water courses.

BIBLIOGRAPHY

Uranium

French: Uranium. — German: Uran. —

Uranium (symbol U) is an element
belonging to the group of rare metals. It is not widely distributed in nature, but enters into the composition of several ores: pitchblende, an amorphous ore containing various oxides of uranium, uraninite (crystalline variety of pitchblende), carnitite (hydrated vanadate of potassium and uranium), etc. The most important deposits are to be found in Bohemia (Joachimsthal), Saxony, Colorado, Utah and Katanga (Belgian Congo). Uranium is a white silvery metal with a silky fracture. Its atomic weight is 238.7, density 18.7, melting point 800° C. It is, however, more volatile at high temperature than iron, notwithstanding the fact that its melting point is higher than that of iron. Though resistant to air at ordinary temperatures, uranium burns with explosion in air at 170° C. When struck by a hard substance, it gives off numerous sparks. With boiling water hydroxide of uranium is obtained. It is readily soluble in the majority of mineral acids and in certain organic acids to form the corresponding salts, the best known of which are uranium nitrate and uranium acetate, used as reagents.

Separation of uranium from ores containing it is usually effected by a wet method. The ore, after being ground, is treated in a hot state with hydrochloric acid in earthenware receptacles. The solution, which contains uranium, is filtered and treated with barium chloride and sulphuric acid in order to precipitate radium and barium in the form of insoluble sulphates. The uranium precipitated with other rare metals, by the addition of iron filings to the liquid is separated by boiling the precipitate in water. There is thus obtained a hydrous oxide in the form of flakes which can be separated off without difficulty.

At Joachimsthal the ore is roasted to eliminate sulphur and arsenic. The mixture of oxides obtained is melted in an electric furnace with a given quantity of carbon. This enables the copper, lead, iron and nickel to be separated in the metallic state, and furnishes as a supplementary product slag containing the lower oxides of uranium and other rare metals (carnotite, molybdenum). The first group of metals is extracted from the mass and the slags are again heated in the same furnace in the presence of carbon. The oxides obtained are thus transformed into carbides which are treated with water in order to separate the uranium carbide, which latter alone enters into the reaction. The hydroxide, after being dried and calcined, is transformed into ferrousuranium by heating in a crucible, or into metallic uranium by aluminothermic processes. It is also obtained at the present time by electrolytic methods.

Uranium has only recently been used in industry to give greater hardness and resistance in tempering steel and to replace tungsten in special varieties of steel.

Uranium is radioactive and is related to radium and helium. When an ore contains uranium it also possesses a definite proportion of radium. The degree of radioactivity therefore furnishes an indication of the contents in radium and uranium.

Salts of uranium are highly florescent. Certain of them serve in dyeing silk; the oxide is employed in the preparation of a yellow glass with green fluorescence which renders visible objects under ultra-violet rays.

In 1854 Leconte issued a publication demonstrating that poisoning by uranium gives rise to glycosuria. According to Kobert, uranium is the most poisonous of the rare metals. Paul Govaerts (1928) has made a study of extravasations which appear during acute uranium poisoning, and Eitel has developed a sensitive process for detecting uranium and localising it in the poisoned animal system. Eitel has succeeded in affirming that in the case of fatal poisoning, all the organs with the exception of the kidneys are unaffected by uranium.

MacNider (1927), Mauriac and his students (1927-28) and Garnier, Schummann and Marek (1929) have studied the toxicity of uranium nitrate, and by injecting subcutaneously a dose of 3 mg. per kilogram caused nephritis, usually fatal in rabbits. With a dose of 1-2 mg. per kilogram it has caused albuminuria always of considerable extent which lasted for eight days. Similar observations have been made by Chittenden, Hutchison and Lambert, Fischer and Hartwich. Worochilsky has produced experimentally, first of all glycosuria, then albuminuria and gastro-enteritis. Death has occurred in doses varying from 1/2 to 2 mg. per kilogram. MacNider recorded and studied lesions of the liver (1927).

Studies of the effect of uranium salts on the human system are very rare;
in 1925 De Laet and Meurice published their observations dealing with four adult workers, two of whom had worked eight hours per day with uranium salts for about twenty months, the other two having been engaged on the same work for fourteen and seventeen months respectively. Only one of these workers suffered after a period of six months from intense purpura of both legs. Analysis of the blood and urine, however, gave positive results in the case of the four workers: reduction of leucocytes, especially in the case of the two handling insoluble salts (contact with the skin and mucous membranes), considerable diminution in the number of red corpuscles (anisocytosis and poikilocytosis), especially in the case of the workers handling the soluble salts.

No glycosuria was noted, but, on the other hand, a certain diminution in the urinary elimination of nitrated salts and a strong increase in the chlorides. Leucopaenia persisted, though to a less marked extent, in the case of three of the workers, two years after they had been completely removed from work involving manipulation of uranium. De Laet and Meurice hold the view that uranium enters the blood stream and is at least partially eliminated by the urine.

Resuming their experiments with rabbits, Garnier and Marek (1931) discovered that by means of acquired tolerance they could bring the animals to withstand daily doses of 10 mg. per kilogram of uranium nitrate, or a dose very much greater than the dose usually considered fatal. Nevertheless, the animal though apparently not showing signs of injury suffered from loss of weight and from albuminuria and glycosuria without hyperglycaemia. Before death the animal showed signs of nervous derangement (loss of equilibrium and paresia of the limbs) and succumbed at the end of three to four months without developing hypernitraemia. The autopsy showed death to have been due to complex lesions: incipient renal and hepatic sclerosis, derangements of the nervous system, atrophy of the optic nerves. It was therefore concluded that cancer can hardly be exclusively attributed to dust inhalation. Moreover, it is still, at present impossible to state with certainty the true cause of the cancerous growth (Pircham and Sikl). (See also article "Radium and Radioactive Substances").

For detecting and localising uranium in the animal system, Eitel transformed the compound present in the cinders obtained by calcination of the organs into a uranyl compound, which with a Hanauer analysis lamp gives a characteristic greenish yellow florescence. (For hygiene and legislation, see article "Radium and Radioactive Substances").

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Vanadium

French and German: Vanadium. — Italian and Spanish: Vonadio.

In 1802, Del Rio reported that he had discovered “a new metallic substance”, which he called “panchrome” or “eritone”, on account of the reddish colour of its salts under the action of acids or of heat, but it was only later that Berzelius provided definite information regarding the properties of this element, which he designated “vanadium”.

Vanadium (symbol V) has not so far been found in a pure state. On this account very little is known regarding the physical properties of the pure metal. Vanadium possesses a strong chemical affinity for oxygen, nitrogen and carbon, and combines with extraordinary facility with other metals. It is almost acid-resistant, and burns with violent projection of sparks.

Vanadium is extensively distributed throughout the earth, though very few deposits are sufficiently extensive to justify extraction. The most important ores are: vanadinite (chlorovanadanate of lead, with about 17 per cent. of vanadic acid), roscoelite (silicate of vanadium and aluminium, with 28.5 per cent. of vanadic acid), carnotite (double vanadate of uranyl and of hydrate of potassium), vanadium sulphide from Peru, with 39.84 per cent. of sulphide, etc.

Vanadic acid may also be extracted by treating basic slag.

In the metallic state it is obtained by bringing to red heat chloride of vanadium in a current of hydrogen or in a less pure state, but in crystals by bringing to red heat in an electric furnace vanadic acid mixed with carbon in a current of hydrogen.

Almost pure vanadium may be obtained by the aluminothermic process, or by the Goldschmidt “thermite” reaction.

Since the metal in a pure state is of no interest whatsoever from the technical point of view, and since on the other hand its preparation is extremely difficult, mention will be confined to the direct manufacture of alloys, and especially of ferrovanadium and other vanadium compounds.

Vanadium is chiefly of considerable importance in the steel industry, this fact being based on its faculty for augmenting the resistance and other important mechanical properties of steel, such as hardness, capacity of resistance to shocks and blows, as well as elasticity.

Though used in lesser quantities, the pentoxide of vanadium (V₂O₅) is used as a developer in photography, and the chloride, as well as the trioxide of vanadium (V₂O₃) as mordants in printing. Another important product is metaammoniate of ammonium (NH₄VO₃), utilised in dyeing with diamond black. Brought to red heat, metaammoniate gives off pentoxide of vanadium.

Vanadium compounds may, in strong doses, prove toxic, and vanadate of ammonium and vanadic dioxide or vanadium pentoxide are particularly toxic.

Vanadate of ammonium is at present largely used in the preparation of blue inks. The habit of putting inky fingers in the mouth may represent a source of danger. Ballotta (1931) has stated that these inks contain 0.005 grm. of vanadate per cub. cm. and 0.003388 of the dioxide.

Animal experiment has revealed the fact that vanadate acts on the vasomotor and respiratory systems: somnolence, clonic contractions preceding coma, have been noted, and at the autopsy intense hyperaemia of the lungs, the intestine and the kidneys.

In experimental poisoning of a more or less serious character, the mucous membrane of the eyes, nose and stomach becomes covered with a greenish coating containing vanadium.
The action of the pentoxide during 20 to 25 minutes in a dose of 0.5 mg. per litre kills an animal in forty minutes. With a dose of 5 mg. per litre during five minutes it is fatal in one hour.

The risk of chronic occupational poisoning is represented by inhalation of pentoxide of vanadium dust during its use in the manufacture of vanadium steel, as a catalyst in dyeing, and for the preparation of vanadium compounds. Poisoning in the case of human beings is manifested (Dutton) by irritation of the mucous membrane of the nose, throat, and conjunctivae; by more or less grave digestive disturbances and derangement of the kidneys (hemorrhagic nephritis); nervous troubles (trembling, headaches, psychic derangement, and even blindness due to neuro-retinis).

Good general ventilation, supplemented where necessary by localised ventilating devices, should be installed in all workrooms where vanadium compounds are handled.

The use of adequate respiratory apparatus in the case of workers specially exposed to dust from this product is to be recommended.

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Varnishes and Lacquers
(Manufacture of)

French: Fabrication des vernis et laques.
— German: Lack- und Firnisfabrikation.
— Italian: Fabbriche di lacche e vernici.
— Spanish: Fabricación de varnices y lacas.

TECHNICAL DATA

The preparation of lacquers and thick varnishes depends on the drying property of certain vegetable oils derived from wood, hemp, poppy, walnut, sunflower seed, soja seed, maize, cotton seed and French turnip, and, in particular, of linseed oil. The latter is subjected to partial oxidation to increase and quicken its drying power, which is done by heating it, between 150 and 320° C., in boilers heated by steam of superheated air, often in the presence of certain oxides or salts such as litharge, minium, metallic oxides of manganese, borates of manganese and of lead, resinites and oleates of lead, of manganese and of cobalt. If the heating is carried out at a moderate temperature, liquid oils, "weak varnishes", are obtained; at higher temperatures, medium, strong, or boiled oils are obtained.

"Blown" oils are manufactured by letting heated oil fall in very fine droplets in a glass cylinder whilst a counter current of oil and ozonised air is injected. These oils are very little used.

"Thick varnishes" are prepared by dissolving melted resin in boiled oils, or by adding, during the heating of the oil, at the same time as the metallic compounds, colouring bodies and melted resin. When the mixture is cooled the necessary diluents are added as required.

The composition of varnishes varies with the nature of the solvent, of the dissolved substances, and with their use. According to the solvent, varnishes are classified as alcohol varnishes or lacquer varnishes; turpentine varnishes; oil or thick varnishes; and various varnishes, made with ether, chloroform, acetone, amyl acetate, carbon disulphide, tar, and bitumen.

By the word "lacquer" is meant the resin which flows from the buds of various trees of the West Indies punctured by Coccus laccas or, when punctured by another insect, Carreria Larrea, from the buds of the Acaca Gryti Gray and of the Larrea Mexicana Mod., yielding American gum lacquer. Japanese lacquer is a milky juice which is obtained by tapping the Rhus vernicifera D.C. and Japanese anacardiaceae (Urushi-no-ki). By filtering crude lacquer under pressure, purified lacquer is obtained which is sticky and of a deep brown colour. This lacquer contains 60-85 per cent. of urushic acid or "Laccol" or "Urushiol", which is a mixture of several substances, one man, while the German word "Firnis" corresponds with the French "huile de lin cuite" and the English "boiled linseed oil" or "boiled oil".

What in French is called "vernis" and in English "varnish" is called "laque" in German.
of which is toxic, and 10-30 per cent. of water, with traces of gummiferous materials and an oxidizer.

In a broader sense, there are included under the term "lacquers", solutions of resins in drying or volatile solvents, which, after application and drying, leave a thin pellicle of the dissolved substance. This word is similarly applied to solutions of other appropriate bodies, which are not resins, such as asphalt, artificial asphalt, artificial resin, nitro- and acetyl-cellulose. Each lacquer is composed of an organic colouring material, attached firmly to some substance which acts as a base or foundation, and is generally a mineral. The colouring material may be of animal, vegetable or synthetic origin. It is attached to the base by mechanical absorption or by chemical reaction; it dissolves in a suitable liquid, i.e. a solvent.

Resins are substances with a somewhat complex and rarely constant composition; they are found in excre- tory products from several trees, or in the fossil state as amber, Dammar copal and Kauri copal, and, more
rarely, in products of animal secretion, as musk and castor. Nowadays, artificial resins are much used; they are prepared by treating natural resins or by dry distillation of certain substances, or by resinification of several organic substances. Synthetic resins should be mentioned, they resemble natural resins, and are obtained by condensation of a phenol with an aldehyde, e.g. bakelite and formolite.

Under the name of copals are understood resins which come from plants of species and families varying according to their country of origin. Copals are distinguished by their source, whether from Africa, Asia, Australia or America, by their properties, whether hard, semi-hard or soft, and by their colours, whether white, yellow or red. Oil of copal is obtained as a by-product during the distillation of copal above 300° C.

Colophane is a residue from turpentine, after the extraction of the oil of turpentine (see that article).

Gum-lacquer, which is put on the market in sticks, grains, lumps or scales, is used for the manufacture of sealing wax, glues, alcohol varnishes, lithographic inks, insulating materials, polishing materials, as a dressing for decorative work, and in the construction of gramophones.

Among other resins should be mentioned acroid resin, which is used in the manufacture of varnishes resistant to light, of resinous soaps or of sealing wax; Dammar resin; benzoin; Elemi; Mastic resin; Dragon's blood; Styrax or Storax, a thick, grey, resinous mass consisting of a mixture of the ethers of cymic acid and resins and obtained by heat and pressure from the internal bark of Liquidambar Orientalis Mill.; sandarac resin, which is found as small yellow grains and is used to manufacture varnishes, glues and dull varnishes used in photography; coumaron resin, which has in days gone by played an important part as a cheap substitution product for colophane and is prepared from solutions of sulphuric acid used for the purification of heavy tar oils.

Artificial resins, soluble in benzene and miscible in oil colours, are used nowadays as varnishes.

Phenols, formaldehyde, vinic acid or other organic oxy-acids are used to manufacture "Lakkaine", a product similar to gum lacquer and soluble in alcohol, ether, acetone, and soda-lye. With other acids or salts, possessing a chlorhydrine acid reaction, other products can be manufactured, such as "Novolak", "Abalak" and "Sibolit".

The use of o-cresol, in place of phenol, gives metakaline (Bayer), isol ine and bucheronium. Substitutes for gum lacquer are obtained with phenols and formaldehyde by the addition of alpha-naphthylamine and by further treatment with oxidising bodies in order to obtain resisting power on exposure to air.

In the manufacture of boiled oils and varnishes, oil of a Chinese wood — oil of Tung — is often added; and there are used as diluents, in place of turpentine, which is costly, pine oil or residues from the manufacture of pine oil, light and heavy oils of camphor, benzene, solvent naphtha, chlorated benzenes, hydrocarbons of the fatty series, but, especially, heavy benzene, sangajol, white spirit, and, less often, light benzene. Spraying oil-varnishes are obtained by the addition of wood oil which dries rapidly.

With regard to the thick varnishes already discussed, the protective pellicle which is obtained is the result of the oxidation and the polymerisation of the oils which combine with the resins in the state of fine division, forming a shining and entirely smooth surface.

The addition to varnishes of this class of volatile solvents, first causes a dilution and it is only afterwards that the above-mentioned changes occur in the constituents of the varnishes. These varnishes are named "volatile varnishes."

Bitumen varnishes, natural or artificial, are solutions of this substance and resins in linseed oil and in one or more diluents. Some varnishes of this group dry in the air, while others must be put into a stove.

The solvents used for alcohol varnishes are denatured alcohol, amyl alcohol, amyl acetate, and acetone. Benzene and petrol are used as adjuvants. Alcohol varnishes, without covering colours, are merely solutions of resins in alcohol solvents. In the same way polishing varnishes are composed of a solution of gum lacquer, wax, turpentine and an alcohol.

Mention must be made of cellulose varnishes, which are volatile varnishes having as a base nitro- or acetyl-cellulose in place of a resin. The solvents used are chiefly acetone, amyl acetate and methyl alcohol, and, as additional products, benzene, toluene, amyl alcohol, chlorated hydrocarbons, ethers and glycol ethers.

The importance attained by the use of these varnishes has obliged the chemical industry to find a large quantity of solvents and diluents, which are often sold in commerce under
fancy names. Moreover, mixtures of these products are often sold without any indication of their composition.

Glycol ethers combine the solvent powers of alcohol and ether, and are used chiefly for the preparation of Zapon lacquers or Cellon. They are often diluted with butyl alcohol and benzene. It would take too long to enumerate here all the products used as solvents of nitro- and acetyl-cellulose (see article "Solvents").

The plasticity of varnishes used in the leather, artificial leather, and film industries, is obtained by means of plasticizing products, among which it is sufficient to mention phosphate of tricresyl and of triphenyl, and the phthalates of methyl, ethyl and butyl. Technical methods still involve utilisation of products to be feared on account of the dangers which they present; mention may be made of tetrachlorehthane, and di- and epi-chlorhydrine.

**Sources of Dangers**

Sources of danger arise principally from the inflammability of the oils, and fumes given off during the melting of the resins or the distillation of the oils; from the risk of splashing by hot oils in the case of workers employed at the cauldrons; from fumes of solvents and diluents, which are readily inflammable and mostly poisonous; as well as from fumes given off during the various operations. Among these last may be mentioned acrolein (see that article) which is rightly feared on account of its irritant action. Furly fixes as a minimum dose which may be endured 70 cm. per cub. metre of air; but even in this weak strength it causes marked signs of irritation.

Risks of poisoning during the preparation of varnishes are not so great as during their use, especially if they are applied by means of sprayers. The reason of this is very simple: during the manufacture of varnishes every precaution is taken to prevent the volatilisation of the solvents and diluents. Instances of damage, chiefly to the skin, from the use of lacquers and varnishes are extremely numerous, and it is impossible to give a complete list of these.

The fact must also be emphasised that the composition of varnishes is very varied; the subject is confused by much genuine and illusory practical experience; and, in practice, a good deal of secrecy is maintained.

The different constituents of varnishes may, under certain circumstances, react one upon another in an unforeseen manner, and cause formation of equally unexpected poisonous substances. But the manufacture of varnishes is becoming more and more scientific, and at present the use of very complicated compounds is avoided; it seems by the suitable mixing with less solvents, to ensure with an equal certainty varnish-mixtures for the various purposes as required.

**Pathology**

Barnes in 1931 described a dermatitis among workers employed in the preparation of linseed oil, which he attributed to impurities existing in the oil cake, and also to personal idiosyncrasy.

Vokonu in 1928 also described a dermatitis due to linseed oil; it was bilateral, with itching, situated on the forearms, and was followed by a papulous eruption and scabs.

The reports of the medical inspectors of Great Britain and Germany record several cases of dermatitis due to lacquers and varnishes, particularly to the synthetic varnishes — nitro-cellulose and bakelite. Attention is rightly drawn to the risk of using nitro-cellulose varnishes for domestic purposes.

Zapon lacquers cause not only skin affections, which are quite frequent in the industries producing or using these lacquers, but also irritation of the visible mucous membranes, headaches, and passing disorders of the liver, which becomes enlarged and painful on pressure, with jaundice and urbinuria. This train of symptoms may be attributed to the presence of tetrachlorehthane, as in the case of Ohnesorge (1930), among hatters. In cases of poisoning observed among the workmen in a pencil factory, there was conjunctivitis, headaches, vertigo, weakness, cough, dermatitis, and congestion of the face, a train of symptoms which may be attributed to the presence of methyl alcohol and amyl acetate.

In 1931 Rouset had an opportunity for studying for a whole year skin affections among workmen at a large factory. These affections presented an extraordinary polymorphism, and were situated on the exposed parts. The onset was sudden, with intense, but transient, subjective signs. Mildness was an almost constant feature. The eruption was generally papulous, very bright red, non-prurigenous and lasted twenty-four to forty-eight hours. Sometimes, the passing erythema showed papular or vesico-papular appearances. Rouset attributed these skin condi-
tions to the effect of wood vinegar, with acetone and methyl alcohol, and of benzene, especially during their evaporation. Although there was certainly an individual cutaneous susceptibility which played its part, the use of these diluents for cleansing the skin was chiefly to blame.

The production of Tonkin lacquers causes among the natives severe dermatitis, with conjunctivitis and keratits.

Darier in 1928 described a temporary eruption of a simple kind among lacquer workers. The vogue of the game of Mah-Jong caused eruptions among players, due to contact with the lacquer covering "authentic" boxes of Mah-Jong. These cutaneous affections, which are well known in China, are due to the presence of Rhus vernix, which is used in the preparation of the varnish and causes a dermatitis characterised by urticaria and arthralgias or by an exanthemous, papulovesicular eruption with oedema and itching.

**HYGIENE**

The old technique for boiling oils, which is still used by many manufacturers, is as follows: linseed oil is put into a cauldron of iron, cast iron or copper, set in a block of masonry and heated at its lower part by flames or hot gases which come from a furnace. The cauldron is equipped with an overflow and a cover which is controlled by means of a cable or a chain. The cauldron is usually surmounted by a movable exhaust hood, connected to a system of ducts, which lead to a ventilating fan by which the gases and fumes are caught up and driven into a condensation apparatus. The non-condensable portions of these gases pass under the bars of a coke furnace kept at red heat. In other systems, a fine spray of water under pressure is directed into the system of ducts. The spray absorbs the gases and fumes and also acts as an ejector. In this way the use of a ventilator fan is eliminated.

The modern method is to carry out the boiling at a very high temperature, say 320° C.; it produces oils with very good drying properties ("Stand-oilies"). Boiling in vacuo, or in an atmosphere of an inert gas, has been tried, but without success. On the other hand, it has been successful with utilisation of carbonic dioxide. By this method it is possible to eliminate many of the disadvantages arising from the old method which affected the neighbourhood and the health of the workers.

The cauldron is made from a single piece, without soldering, and the gas, when introduced under pressure, causes a suitable agitation of the boiling oil. The apparatus is supplied with a condenser for the volatile condensable products, which are, however, small in amount. The heating is by gas-coke, or gas, or heavy oil.

Other kinds of apparatus possess an overflow for the oil which may run over during the boiling. The oil which has overflowed is returned to the cauldron by means of the pressure of carbonic dioxide.

By these methods boiling can be done at high temperatures without any fear of the oils becoming deep in colour.

The manufacture of varnishes with a copal or resinous base, with the addition of linseed oil and solvents, is carried out in an apparatus in which the products can be manipulated by means of pumps and carbonic dioxide under pressure. The volatile condensable products are condensed by a special refrigerant; what escapes is caught and condensed by spraying with water. The non-condensable gases are passed into a special oil furnace, where they are burnt.

In a similar apparatus, but provided with a mechanical stirrer, the boiling of oils is done at a low temperature, 200-220° C., with or without incorporation with metallic bases. In this case, also the fumes given off are condensed.

As regards solvents, some apparatuses only effect an imperfect condensation of the fumes; others, by an improved system of agitation, eliminate most of the condensable products. The best solution is provided by arrangements which make it possible for the residuary gases to be burnt. The recovery of volatile solvents — very important from the point of view of economy — which are found in the form of fumes in the air or in the gases can be effected by condensation, by compression, by adsorption or by absorption.

Nowadays an apparatus exists which makes it possible to determine the limits of the explosion of solvents at ordinary temperatures in a satisfactory manner. Solvents with a base of alcohol or of ethers can be concentrated much more than those with a base of hydrocarbons before becoming explosive. Mixtures of alcohols and ethers distilling above 150° C. do not explode at ordinary temperatures; on the other hand, when they contain a certain proportion of hydrocarbons they rapidly become explosive.
By ventilation the limits of explosion can be controlled considerably. Thus modern apparatus eliminates the disadvantages of the old methods almost entirely: danger from spontaneous combustion of the oil, and of the fumes generated; danger of fire; disagreeable smells; serious burns for the workers; and irritation of the mucous membranes by the fumes and especially by acrolein.

The manufacture of thick varnishes, whether it includes the boiling of oils or not, and the boiling of oils in any way whatever, are in some countries, e.g. Belgium, France and Italy, classified in the first category of unhealthy and offensive trades. This classification requires the adoption of the following measures: (i) the work must be carried on at a distance from dwellings, on account of the disgusting and irritating odours and of the dangers from fire and explosion due to melting resins and boiling oils, the vapourisation of liquid hydrocarbons, etc. (ii) workshops must be constructed of light, non-inflammable materials; (iii) tanks of inflammable liquids must be more than 10 metres from the furnaces or heating for the plant, and surrounded by a watertight fire-resisting casing, capable of receiving, if required, the whole of the liquids.

Operations which are liable to give off disagreeable fumes must be carried out in closed apparatus. The dispersion into the outside air of disagreeable emanations and furnace fumes cannot reach the furnaces. The manufacture of solid driers by melting, and pouring of resines or linoleates must be prohibited. In case of a break in the apparatus, burning liquid must be prevented from spreading outside the workshops or reaching the tanks. Fire-extinguishing apparatus must be always at hand, and the workmen must be trained in their use. Risk of fire can be reduced by suitable storage and manipulation of solvents and nitrocellulose; and by close supervision of such electrical equipment as motors and lighting, of machinery, of fans which create danger from static electricity, of the heating, of tools, and of the tidiness of the factory by avoiding accumulations of greasy rags. The exit of workers in case of danger must be rendered easy.

The importance of thorough ventilation of the workshops must be emphasised, as likewise that of installing electric lighting provided with efficient protection against the production of sparks, especially where the solvents are stored, and of the provision of a sufficiently high chimney reaching from 20 to 30 metres. The addition of volatile solvents to melted resins should only be done when the contents of the cauldron are sufficiently cool. Diluents should be used with a high boiling point, so that when they are added to the hot oils and varnishes there does not occur too great a loss by the formation of fumes. The mixing shop should be provided with efficient exhaust ventilation so that the inflammable fumes cannot reach the furnaces.

The fumes and vapours which occur in varnish works are: (a) volatile products which come from the partial decomposition of resins and oils while melting or boiling; (b) fumes from the furnaces; and (c) vapours from solvents.

Transfer of these products into an incinerating apparatus involves an enormous expense for the industry and a definite loss of volatile products which can be recovered.

It is much better to eliminate these products by the use of condensation and by causing them to pass through an alkaline solution. The air of the workshops is aspirated and passed through a condenser which is a long metal tube, where it gives up products of high boiling point. Any fumes which remain over must be removed by absorption in an alkaline solution (Perry-Webster system).

The individual protection of workers calls for attention. Care should be taken that the working clothes are not soiled by oil, varnish or solvents, as that constitutes a danger to the men in case of fire. The usual measures of personal hygiene must be adopted.

See also the Memorandum on risks from accidents and injuries due to cellulose solutions and on the measures to be adopted to prevent these, issued by the English Factory Department in 1928.

LEGISLATION

Women are excluded from varnish works in Argentina. In Belgium, young persons under sixteen years are excluded from boiling linseed oil on a large scale, from varnish factories, and from applying varnishes hot. In Spain, boys under sixteen years and women under twenty-one years are excluded from using varnish with a base of rubber, which would expose them to the action of fumes of carbon bisulphide, benzine and hydrocarbons.

Existing legislation has dealt particularly with factories for varnishes and lacquers which have a base of lead compounds. As regards the other varnishes and lacquers, the measures laid down for the chemical industry, hydrocarbons, etc., are valid (see those articles).

Dermatitis and eczemas caused by varnishes and lacquers are subject to com-
pulmonary notification in the Netherlands. Injuries caused by acetate of cellulose varnishes used in aeronautical work are compensated in Great Britain; injuries due to the preparation and manipulation of varnishes, glazes, mastics or dyes containing lead compounds are compensated in Belgium, France and Italy (see, with regard to this, article 'Painting'). As regards the other solvents, see article "Solvents" and those relating to various products used as solvents or diluents.

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Ventilation


Ventilation is essentially a technical problem, having for its object not only provision for the renewal of the air in workrooms, but also for rendering atmospheric conditions in them as perfect as possible.

The problem is to effect on the one hand the removal of vitiated air arising either from occupation or the carrying on of industrial processes in workrooms, and, on the other, to replace the air removed by fresh air conforming to requirements of chemical purity, temperature, humidity and movement.

Physiological investigations in recent years (see article "Air of the Workrooms") have made it clear that, apart from the problems created in certain industries by poisonous fumes and by toxic or irritant dusts, the general effects of bad ventilation are due primarily not to any chemical vitiation, but to overheating and stagnation of the air and the effects of such overheated stagnant air upon the rate of heat loss from the surface of the body. The fundamental object of ventilation (except where toxic dusts and fumes are dealt with) is to remove the warm air heated by the oxidations of the human body and to replace it by cool, but not cold, air of moderate, but not excessive, humidity and in moderate, but not excessive, motion.

The first step in securing good atmospheric conditions is therefore systematic observation of the temperature. No schoolroom, no factory workroom, no office, no living room, should be considered as furnished, and fit for human occupation, without a thermometer. Furthermore, a thermometer is of no value without someone to read it; therefore it should be the definite duty of the foreman in the shop to note the temperature at fixed intervals. The regular reading of the thermometer is the first essential in the control of air conditions; and whenever the temperature exceeds 20° C. something should be done to remedy the situation.

Where an unduly high temperature exists, the first thing to be looked to in considering its cause is the question of artificial heat sources. It is very frequently the case that overheating is due, not at all to lack of ventilation, but merely to the fact that radiators or registers are pouring too much heat into the room. Anyone who has an opportunity to study a wide variety of ventilation problems will recall numerous factory workrooms, for example, in which the radiation is turned on full force in October and left turned on till May, with no reference whatever to atmospheric conditions. It is obviously impossible then to consider ventilation intelligently without considering heating as well. There are three methods of heating rooms which are in common use: (1) direct heating effected by radiators or other heat sources within the room itself; (2) indirect heating, effected by supplying to the room air which has been previously heated elsewhere as by a furnace or a plenum-ventilation plant; (3) direct-indirect heating, a combination of the other two in which the heat of the room is partly supplied by warm air entering it and partly by local radiators.

Either direct or indirect systems of heating can be controlled by automatic thermostats. These are devices in which the differential expansion of two suitable metals controls radiator valves or dampers in the air ducts. When in good working order such thermostatic systems are highly efficient. In a certain mechanically ventilated school in New York City, for example, where the thermostats were carefully adjusted, 143 different observations of the room air showed 124 records between 18° and 21° C., with 3 below 18° and only 3 above 22° C. On the other hand it must be recognised that thermostatic systems very easily get out of order. When the same school cited above was visited a few years later its temperature control was found to have become so imperfect that the experiments contemplated had to be transferred to another building.

It is obvious that even where automatic temperature apparatus is installed its operation must be checked up by thermometer readings; and where no such devices are provided frequent attention must be given to radiators and registers.
in order to see that they are not doing harm rather than good.

When a number of people are crowded together in a schoolroom or an office a new problem arises, distinct from that of the control of artificial heat sources — the problem of getting rid of the heat produced by the vital processes of the body. The average human being gives off about 100 calories of heat per hour. An occupied room will therefore become progressively warmer all the time (except in very cold weather when heat losses through walls and ceiling are extreme). The primary objective of ventilation is to compensate this bodily heat production; and there are two general ways of doing this, by natural conditions is greater the greater is the difference in temperature. A chimney likewise acts similarly even when there is no fire.

In these circumstances use is made of the natural openings as inlets for air and the chimney as an outlet.

Sometimes violent draughts may be created by opening doors and windows; but this method, which can only be done in small premises and during intervals of work, presents numerous objections (imperfection of the ventilation, insufficient result, chilling in winter; introduction of dust in summer, etc.).

or gravity ventilation and by artificial or fan ventilation.

1. NATURAL VENTILATION

Circulation of air is always taking place between the inside and outside of a room through openings, the interstices of doors, windows, thicknesses of walls more or less impermeable. It is noteworthy that this natural ventilation is so much the more efficient, the greater the difference in temperature is between the two. Wind acts in the same way, and its action under cer-

The simplest method of ventilation is seen in the window which, if adequately arranged, is very useful for the purpose. Cold air travels downwards to where it is warm, so that it suffices, for example, to open the windows on the first floor on the sunny side and on the ground floor on the opposite side in order to secure a thorough ventilation of the place. On a single floor good results are obtained by openings in the lower part of the windows on the shady side and at the top on the sunny side.

Effort has been made to solve the
problem by making use of various special openings placed in the panes of glass of the windows.

In these instances the chimney usually serves as the outlet. But all sorts of ventilating vents (Tobin’s tubes, etc.) are found. Outlets are also provided by ventilators in the roof, lanterns, hoods with exhausts, chimneys connected with the ceiling, etc. Shafts connected up to exhausts or chimneys are also used. In order to prevent reflux of air when the direction of the wind changes, movable revolving cowl, the action of which is well known, are affixed to the extremity of the chimney or lantern.

This ventilation, to be efficient, must be arranged in such a way that the ventilating shafts are properly placed. The air should be made to arrive in summer at the level of the floor, and in winter at the level of the head or higher, unless special means for handling the incoming air have been provided. The outlets for air should be in an opposite position, and all the openings should be provided with means for closing and regulating them: blinds, shutters, Venetian blinds, etc. The openings at the outlet at the level of the roof should be protected either by a fixed arrangement or by some form of revolving cowl moving with the direction of the wind: with the object of preventing the return of air into the ducts, and to assist the action of the wind as an aspirating force. These installations work even with a difference of temperature of 5° C., but the output is improved by artificial heatings at the inlets and gas rings in the outlet shaft, etc.; this can double or even increase the output by five times.

Where it is a question of the removal of heavy gases and fumes recourse must be had to powerful suction which is often disagreeable and even dangerous for the persons employed. Further, under the roof or close to the walls vertical dead ends may form when the gases may go round in a circle without being removed, and where sometimes the ventilation takes on a reverse direction.

Effort has been made to reduce to a minimum this excess of pressure by the combination of a fan with a kind of ejector (“induced draught”), and by using — as a means of getting rid of the gases — conical diverging diffuser. But this apparatus has its drawbacks; and consequently for some years another method has been adopted (Channard-Etoile) which obviates altogether louvres and flues, ensures a good draught at all times and requires no attention. This is simply a cylindrical cowl closed entirely at its upper surface and communicating with the outer air by seven vertical openings demarcated by projecting paddles and constituting the channels of outlet for the escape of the gases to the outside and inversely preventing the passage of gaseous currents which might try to enter from the outside air into the chimney. The ratio of the resistances offered to the passage of the gases as they go out and come in is of the order of 10 (for the gases trying to enter) to 1 (gases going out).

This apparatus, which is made in sheet iron, cement or fireclay, or other acid-resisting material, can be applied as easily to roofs entirely of glass as to chimneys or to exhaust shafts over hearths or boilers. The slightest breath of wind sets the ventilation going without any trouble; the strongest draughts do not interfere with its action, nor do the sudden starts of the slightest back draught. This form of natural positive ventilation without mechanical parts is used widely in factories for the removal of steam, hot air, poisonous gases and air thick with dust, etc.

It would seem, however, that the simple system of horizontal wafters (Knappen system), used in recent years, is not open to most of the criticisms directed against natural ventilation.

Exhaustive experiments conducted by the New York State Commission on Ventilation in America have led to the conclusion that the best system of ventilation for the average schoolroom is a system of modified window-gravity ventilation; and this system is likely to prove entirely adequate for the small factory workroom unless special heat sources, such as annealing ovens, forges, etc., are present and unless the processes of work lead to the liberation of objectionable fumes and dusts.

The system in question involves three essential elements: (a) the admission of air at the windows over slanting window panes so placed as to deflect the incoming air upward and to mix it gradually with the air of the room; (b) the placing of radiators beneath the windows so as to temper this incoming air; and (c) the provision of a gravity exhaust duct to remove heated air from near the ceiling.

In order that the window-supply gravity-exhaust system may operate most successfully it should include the following provisions:

(a) Radiators must be located beneath the windows and extend for the full width of the windows from which the air supply is to be derived. These radiators, being much larger than
those customarily installed in ordinary plenum systems, should be either automatically controlled by intermediate acting thermostats or equipped with fractional or modulating hand-controlled valves, placed at the top of the supply end of the radiator. Even when automatic control is included it is best to supplement it by the provision of hand control as well; and standard metal radiator shields are desirable to protect those nearest the radiators from excessive heat.

(b) Deflecting boards of some satisfactory type should be placed at the bottom of the windows. Devices which include small box-like openings, and devices which involve the use of filtering screens of various types are undesirable. A plane glass deflector one foot high is fairly satisfactory, but the best results may be obtained by the use of curved vane deflectors which secure the most equable distribution of the air.

(c) In order to avoid certain practical difficulties it is recommended that windows should be so constructed as to open easily from the bottom, and that window shades should be firmly attached to the window frame, the best arrangement being that which includes two shades anchored midway between top and bottom, one to be pulled upward and the other downward, these shades being so guided by cords and pulleys as to avoid the shaking of the screens by the incoming air flow.

(d) Exhaust ducts having a total area of not less than 0.75 sq. m. for a room of 450 cu. m. capacity containing some fifty persons should be provided on the wall opposite the windows. These exhaust openings should be conveniently dampered so that their area may be adjusted to varying weather conditions. The exhaust ducts should be carried up through the interior of the building so as to avoid chilling and the tendency to back drafts should be further reduced by placing an aspirating cowl on the opening at the roof and perhaps by placing heating coils in the exhaust duct.

Such a system of window-gravity ventilation, in a workroom of the type described, will effect an air change of 30-50 cu. m. per person per hour and will keep the carbon dioxide content of air generally below 8-10 parts per 10,000, an entirely satisfactory result in the light of modern knowledge.
2. Artificial or Fan Ventilation

In large workrooms, (containing more than fifty employees) and in workrooms where the heat produced by the human body is supplemented by the influence of special heat sources, window-gravity ventilation will generally not suffice and recourse must be had to a system of forced or fan ventilation which may be of three principal types:

(a) exhaust ventilation: air is drawn from a room by appropriate fans, the renewal of air taking place automatically from natural openings or from inlets suitably placed at distant points;

(b) pressure system of ventilation: the air is driven into the workroom by means of fans and a system of pipes provided with openings; the air escapes through special openings or through doors and windows;

(c) mixed ventilation: a combination of the two systems.

Whatever be the system adopted, two other questions of the first importance arise: choice as to the air to be introduced into the room and its distribution.

The air should be as pure as possible, freed from dust and germs and toxic or unpleasant gases and vapours. In some cases the filtration of the air before its entrance into the workroom may have to be effected. The air should be drawn from a certain height, by means of ducts outside the zone where the prevalent winds might contaminate it. In summer, if necessary, the air should be freshened and in winter warmed beforehand, in order to keep the atmosphere within as good limits of temperature as possible.

Distribution should be such as to allow the air to enter and reach the workers in a pure state, without setting up unpleasant draughts. If the incoming air is cooler than that of the room, it should be brought in at a low level and be removed above. Warmed air should be introduced at a higher level. It is known that air as it cools tends to fall; this is why outlets should be at the floor level. It is advantageous to multiply the points at which air enters and contaminated air goes out.

The common arrangement of placing a propeller (helicoidal) fan in one wall and on the other another extracting fan of the same capacity is not altogether satisfactory, because experience has shown that, unless the air is well stirred up, a direct draught is set up between the two fans and the air in the lower portions of the room is not at all, or only slightly, renewed. The workers, too, placed in the line of the draught are too often inconvenienced and liable to take a chill.

A. Exhaust ventilation is the procedure generally adopted because it is the most direct, the simplest, the cheapest to install, the easiest to maintain, while being at the same time very fairly efficient. The most efficacious method is to arrange for thorough ventilation by means of fans placed on one side of the room and inlets on the opposite one. When the workroom is very large the fans can be placed on both sides, the air inlets being in the centre. The main advantage of this arrangement is that a minimum force is needed to ensure the mixing and movement of air.

The necessary exhaust draught is provided by mechanical means: air pumps, piston machines, etc., are now replaced by fans which have many advantages, furnishing as they do unlimited quantities of air; they are controlled easily; allow of changes in the physical qualities of the air as regards temperature, humidity, etc.

Generally helicoidal propelled fans working at low pressure are used (Backmann ventilating fans). Although the types vary very much, according to the forms given to the blades, they have nevertheless characters in common. They are made up of inclined blades, each being a portion of the thread of a screw. The blades mounted on an axis are either belt-driven or are set in motion by a motor. The direction of movement is from left to right, and the air drawn from the belt-driven side is discharged on the other side of the fan. When this acts on a closed room it commences to extract a certain quantity of air, so that the remaining air is under a negative pressure as compared with the external air. In these circumstances, especially when the revolutions of the fan are numerous, as much as 8-10 mm. of vacuum is reached — a limit which should not be exceeded.

Some details on this subject may not be out of place: the shape and position of the blades of the fans are calculated so as to yield a maximum output. Each fan has further, in relation to its construction, a more or less determined limit of variation in velocity for its maximum output, the yield varying directly with the velocity. The output of a given type of fan, making a prescribed number of revolutions and running under suitable conditions of air circulation, is proportional to the velocity and the cube of the diameter.
of the fan according to the formula $C = K \times D^3 \times N$, where $K$ is a constant, $D$ the diameter of the fan, $N$ the speed of revolution per minute, and $C$ the output per minute. The value of $K$ varies with the make and in particular with the inclination of the blades. Practically it oscillates round the figure 0.6. The number of blades is usually six, sometimes eight, but never more.

The fan only works correctly against a slight resistance, allowing of a minimum expenditure of energy. Naturally the output diminishes as the resistance increases. The conditions for successful working are:

(1) Plenty of air in the room where the fan is placed, and several correspondingly large air inlets.

(2) Arrival of fresh air at the point of aspiration. If the fan is placed at a level higher than that at which the exhaust is required, a hood must be placed round the fan sufficient in size not to interfere with its proper working.

(3) If the fan is placed in a corner of the room, a duct should be placed along the opposite side with openings increasing in size the further they are from the fan, so that the air drawn in at each opening should be as nearly constant as possible. The duct in this case should have a diameter equal to that of the area of the blades of the fan, and should have smooth and straight walls.

(4) Free discharge for the air. If this is made into a chimney, it should have a cover as a protection against the rain, placed high enough and wide enough to prevent blocking it up. If the discharge is made into a duct, the diameter of this duct should be greater than that of the fan. If the fan is placed at an angle of 45° to the duct, the junction should be curved so as to avoid friction and increased resistance to the discharge. (See also article "Dusts, Fumes and Smoke".)

(5) The fan should have protection against the wind. It should be placed at the side opposite to the prevailing winds; sometimes the outlets are sheltered so as to make the removal of vitiated air more successful.

(6) A sufficient speed of the fan should be maintained, having relation naturally to the work demanded of the fan. The speed should be meticulously

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Fig. 195. — Ventilating piping in the packing department. (Hoshi Pharmaceutical Co., Ltd., Osaki, Japan.)
regulated, because if it is more than 83 m. per minute, even with air reasonably warmed, either before or on its entry, disagreeable draughts are felt near any openings. If, however, the air entry is arranged at a point above the heads of the workpeople, and if it is sufficiently warmed, a higher speed than that mentioned can be borne. The total minimum surface area of the inlets should be three times the disc area of the fans. If the latter have a greater speed, this minimum must be correspondingly increased.

Finally it should be remembered that the power of a fan varies as the cube of the velocity. Better results, therefore, are obtained by maintaining a moderate velocity from several fans to ensure the amount of air necessary. No fan, however, ought to run at a velocity lower than that of its limit of maximum yield. According to Walker the consumption in h.p. is given by the formula:

\[ Q^2 = 0.0000115 - \frac{h.p.}{D^4} \]

where \( Q \) is the output in volume per second (1/60° of C; see preceding formula) and \( D \) the diameter in cm. The power necessary to ventilate a room of 30,000 cu. m. with six changes of air an hour per week (say 180,000 cu. m.) is less than one h.p.

B. The second system is *pressure ventilation*, that by exhaust draught being insufficient to ensure very great changes of air. This system enables the air in a workroom to be diverted to selected points, distribution being effected by suitable piping.

Pressure ventilation is a suitable method of distribution of fresh air to places where work is carried on at high temperatures (glass furnaces, casting, etc.). It is suitable also for ventilating underground or other premises which, owing to their situation or surroundings, are difficult to ventilate by exhaust.

The types of fans used are extremely numerous; but those mostly employed to-day are high-pressure centrifugal fans. They consist of vanes mounted on a circular frame often assuming the form of a cone like the turbine. The whole turns around an axis in the direction of the concavity of the vanes and is enclosed in a metallic envelope with an opening of large diameter on one side, situated concentrically to the axis called the “eye”. On the other side is the frame supporting the envelope and axis of the turbine. The fan is belt driven, worked by a pulley, or set in motion directly by a motor. The air enters at the eye and is driven out on the opposite side, having been forced against the periphery by the vanes, and is thus driven into the room or along the piping.

According to Boulin and Leclerc de Puligny a fan with vanes 0.60 m. in diameter sets up a negative pressure of 40 to 300 mm. with from 900 to 2,500 revolutions a minute. The output increases proportionately from 640 to 1,700 litres.

The ventilation of large workrooms is carried out under an average pressure of 7.5 cm., the pressure corresponding with the output of a given fan. It is, however, not possible to lay down any simple law for these types of fans as can be done for low-pressure volume fans. Every change in velocity modifies the pressure in the system. Further, the fan can be connected up to main and branch ducts and to installations having different resistances to the air movements.

For a constant resistance the following laws hold:

- The volume discharged by a fan is proportional to the angular velocity, or rather to the circumferential velocity, that is, to the number of revolutions;
- The pressure produced is proportional to the square of the angular velocity;
- The power taken at the brake is proportional to the cube of the velocity.

In practice, use of fans with low pressure and ducts of large diameter is to be recommended, for it would be a waste of useful energy to displace large quantities of air for general ventilation by means of great velocities and piping of small section.

The pressure system increases, although only slightly, the pressure in the room ventilated; and this causes the imprisoned air to escape at all possible openings that can be found. Consequently to ensure good circulation of air it is indispensable to provide suitable outlets arranged on the same lines as those for exhaust ventilation.

*Plenum* ventilation is often combined with air washing or artificial humidification. In such a system the incoming air is first heated to a moderate degree (10° to 21° C. depending on various conditions) by passing through *tempering coils*, which are lines of steam piping like those in an ordinary radiator, but so constructed as to pre-
sent the largest possible surface to the rapidly moving air. From the tempering coils the warmed air passes through a spray chamber or humidifier. This is a chamber filled with a fine mist of water produced by some form of spray discharge, and at its outlet end the air passes between a series of overlapping eliminator plates or baffles which change its direction suddenly many times. Contact with these baffle plates removes the excess of moisture which drains off from the eliminator to a collecting pan below. Three things occur in the spray chamber, when it operates success-

fully. The air is humidified nearly to the point of saturation. It is cooled by the loss of the amount of heat required to transform the water taken up from the liquid to the gaseous form (2° to 5° C. in summer time), and it is washed free from a portion of its suspended dust particles.

Finally, on leaving the spray chamber the air passes through a second set of heating coils, where its temperature is brought up to the final point desired, ranging from perhaps 15° C. where the removal of the heat produced in an auditorium is necessary to 65° C. where a large amount of indirect heating must be accomplished.

The temperature of the air delivered by the fan may be regulated automatically by thermostats controlling either sections of the heating coils or dampers which admit a varying proportion of by-passed air, not exposed to the heating coils at all. The humidity of the air delivered can be regulated by controlling the relative temperatures of the tempering and the final heating coils, since the air passing the humidifier is supposed to be saturated at the temperature at which it leaves the spray chamber, and its

final humidity will obviously depend on the increase in temperature to which it is subjected after this point.

From the fan chamber, the tempered air is delivered to the various parts of the building by a system of ducts carried up, through, or along the walls. It may be pointed out that many systems of fan ventilation in actual use fail to give satisfactory results because the ducts are so imperfectly proportioned as to distribute the air unevenly between the different parts of the building. The problem of the proper proportioning of air ducts

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**Fig. 196.** Ventilating piping in a chemical laboratory. (Hoshi Pharmaceutical Co., Ltd., Osaki, Japan.)
is by no means a simple one, as emphasised particularly by the studies presented in the Second Report of the British Departmental Committee on the Ventilation of Factories and Workshops (1907). It is important that individual duct dampers should be provided so that the air supply to each room can be independently governed; and by somewhat elaborate but wholly practical systems of double or individual duct ventilation even the temperatures of each room can be separately controlled to meet varying conditions of weather and occupancy. Where air is delivered to a large factory workroom by a long duct running along the ceiling it is common practice to construct the duct with a tapering form, becoming gradually smaller from the inlet to the outlet end. Recent studies have shown that a uniform straight duct is likely to give quite as good results; but the section of the main duct should in any case be some 20 per cent, in excess of the sum of all subsequent branch ducts. It is most essential that branches departing from the main duct be slanted forward in the direction of the main current so that the air will not be subjected to a change in direction of more than 30°.

Even with a well thought out system a great loss in efficiency results from eddies at the point where the air flow is changed, particularly with the branch ducts and at the level of the openings placed at intervals along the sides of the pipes. Adequate arrangements allow of remedying this inconvenience. Cleaning of the piping, it should be remembered, should be done at openings specially arranged at suitable points.

By this system the air, as has been said, is led generally to the points of distribution along cylindrical metal pipes placed above the heads of the workpeople; but the discharge points should be placed so as not to cause draughts striking directly on the persons employed. On the other hand the air ought not to be made to enter too close to the ground, as this would raise the dust and dirt and might cause trouble of another kind.

The linear velocity of air maintained in systems of fan ventilation will usually vary from 400 to 700 m. per minute in the main duct near the fan. As the air passes through horizontal branch ducts and vertical stacks its velocity is gradually reduced and at room inlets it is usually between 100 and 300 m. per minute. It is desirable that it should not exceed 100 m. per minute at such points in order to avoid unpleasant draughts. If, then, it is desired to provide an air supply of 1 cu. m. per person per minute the inlet registers in any room should have a total area equal to 0.01 sq. m. per capita.

C. The third system finally is only a combination of both the exhaust and pressure systems. In this case exhaust fans are used in conjunction with centrifugal ones. The first are installed in relation to the air inlets so as to ensure complete ventilation of the room with such movement of air as is necessary for the position at which the work has to be done. In large sheds even it is possible with a good system of ventilation to avoid stagnant pockets of air. Installations of locally applied ventilation are, therefore, desirable at times in addition to general ventilation.

Where special heat sources, such as forges, melting pots, annealing ovens and the like are present, and where toxic fumes are generated, it is essential to install special local exhaust ventilation, sufficiently powerful to remove the toxic or otherwise harmful substances at the point where they are produced. In such cases the sources of the heat or fumes should be equipped with hoods connected by ducts with exhaust fans which, if properly designed and operated, often prove highly efficient. It is, above all, in connection with grinding and polishing wheels and similar dust-producing devices that the principle of local exhaust ventilation finds its most general application. The chief conditions essential to the success of an exhaust system for the removal of dust from grinding and polishing wheels are four in number: the design of the hoods themselves, so that the point where the dust is generated may be covered as completely as possible without interfering with the work, and as closely as possible so that a full suction velocity may be maintained; the arrangement of the suction draft so that it may operate with, and not against, the centrifugal force which throws the dust particles from the wheel; the elimination of all obstacles between the hood and the main exhaust duct which may decrease the velocity of suction; and the maintenance of an adequate suction head in the main exhaust duct itself.

Observations made by Greenburg show that such systems of special exhaust ventilation may keep the air of a grinding shop almost as free from dust as the atmosphere of an ordinary room. In one typical workshop, with forty-nine polishing wheels more or less constantly in operation the dust
content of the air was kept down to 8,000 particles per cubic metre with the exhaust system in operation, while when the velocity of the exhaust fan was reduced the count rose to 30,000 particles.

Modern research and experiment have tended to reverse the views held up to now. These were during the last forty years that the optimal conditions of a good system of ventilation were intense renewal with a very low velocity of the air close to the occupants (plenum system). To-day, according to the reports presented to the second Congress on heating and ventilation (Paris, 1925), the view is held, especial-

ly in towns where the air which is drawn in is likely to be dirty, that circulation in a closed circuit, treating the air, in its passage through the premises, so as to rid it of mineral or organic dust by washing and freeing it of smells and micro-organisms by filtration (ozonization) offers the best conditions.

An average renewal of 50 cu. m. per head per hour would involve a considerable expenditure in fuel. Effort is made to economise by first applying a partial recirculation of the air. The experiments of Larson (1916) show that, with a temperature of 19.5° C. and a relative humidity of 60 per cent. 20 parts per 10,000 of carbonic acid are found, and an economy equal to 40-50 per cent. in fuel is effected.

It is not necessary to cite here the accounts of General Morin (1869) according to whom 30 cu. m. of air per head per hour, replacing 15 cu. m. in a textile factory in France, reduced the daily absenteeism from sickness from 10-12 to 3-4, and increased production by 6 per cent., nor need there be quoted in detail the results of the enquiry by the Inspector of Factories, Williams, of Manchester, after the coming into force of the Cotton Cloth Fac-

Fig. 197. — Ventilation and humidification in a weaving shed (by cooling in summer and warming the air in winter). (Installed by Kestner and Neu of Lille.)

ories Regulations limiting the maximum proportion of carbonic acid gas allowed (diminution in sickness rate, increase in wages, better quality of production, etc.). It is well, however, to recall the data collected by the British Minister of Munitions during the war: good ventilation increases output by about 12 per cent.; output falls off in summer by about 3 per cent., even if the workroom is well ventilated; by 10.4 and even 13.4 per cent. if it is badly ventilated. In Italy Loriga obtained the opinion of a glass manufacturer who assured him that, by the installa-
tion of a good system of ventilation over the glass works, he had obtained a constant output all the year round. Finally, the Hamilton Watch Company of America has stated that with a good system of ventilation the personnel was able to produce in a nine-hour day what formerly they did in a ten-hour day.

**Heating the Air**

The air requires to be warmed when it is taken from outside in winter or when heating is necessary on technical grounds. The inlets should be arranged behind the heating apparatus (several factories utilise the furnaces or boilers for driving machinery), or are surrounded by either steam pipes at low pressures or by hot water pipes from contact with which the air becomes heated to the desired temperature. The heating system with low pressure steam pipes would seem to be the best, the heating surfaces not being so great as with the hot water pipe system. Whatever be the means used, they must be such that, apart from the action of the fans, warm air tends naturally to come into rooms to be ventilated and not to go out by the openings intended to act as air inlets. When it is a question of plenum ventilation, the same arrangement is made (batteries of pipes or radiators) placed in the main duct not far from the fan.

**Freshening the Air**

In the course of a warm season for certain operations done close to where there is a high temperature (glass works, foundries, etc.), it becomes necessary to freshen the incoming air. This is effected by making the air pass through subterranean channels where it is cooled. Or a diminution in the temperature of the air can be obtained by means of water either by contact or evaporation.

The question of humidification of the air is without doubt of the utmost importance. This problem confronts every manager of a textile factory, as well as every manager of a works in which it is necessary to avoid all drying by the atmosphere. Therefore humidification and ventilation should be combined, and not infrequently with heating also. The object sought is to maintain a hygrometric state sufficient for carrying out the process which is as little harmful as possible to the health of the workpeople, while at the same time renewing the air to be breathed.

Textile fibres are hygroscopic and work more easily if kept in an atmosphere the temperature and humidity of which are suitable. For long it has been known that certain regions favoured by a moderate temperature and a humidity sufficiently marked in degree enable counts to be spun finer than can be spun in other districts. Hence the necessity in other regions of humidifying the atmosphere artificially.

The first humidifying apparatus consisted of moist surfaces utilising natural evaporation (vats or troughs in which hot or cold water circulated) cascades or travelling bands of cloth moistened by water of different temperatures and placed in or near a draught. Subsequently recourse was had to artificial evaporating apparatus, various forms of humidifiers, etc. The first encouraging attempts at humidification and ventilation date from 1899-1900. But the problem of humidification is rapidly converted into a more complex problem: that of freshening. There is no need, as is brought out in the article on "Air—Hot and Humid", to try to maintain in spinning and weaving sheds a relative degree of humidity without fresh air, on the ground that draughts would be injurious to the technical process. Years ago, in their construction and technical arrangement, effort was made to avoid all contact with the external air; the spinning rooms were placed in the centre of the building, surrounded by other work-rooms; the roofs were of double glass; there was no removal of the air, etc., which entailed serious injury to the health of the persons who were compelled to occupy the rooms. This was the time when a "draught" was synonymous with "fresh air".

Modern installations, on the contrary, are based on the principle of introducing moist air instead of removing the warm air to the outside and of placing the shed under a positive pressure instead of a negative. Freshening the air is thus strictly linked up with ventilation and humidification. The apparatus that may be used to attain the object desired depends on incorporating water with the pure air by prolonged contact of the liquid with the gas, or by pulverising or intricate mixing, or by humidification obtained separately from ventilation. Of such apparatus there are three distinct forms: (a) the saturators which humidify and refresh, making use of air that has been prepared beforehand in chambers or special apparatus. The air carries with it the quantity of water corresponding with its degree of saturation; (b) the vaporisers in which the second completion is effected in the shed because the air draws with it, in the form of a mist, atoms of water which thus evaporate a second time; (c) the saturators in which the air is prepared in the shed and not in special chambers; the ventilation accompanies and assists in the evaporation of the water, and this work is effected in distinct apparatus.

The installation of the humidifying and ventilating plant ought to be taken into consideration at the time the factory is built. The air prepared in a special chamber is distributed through the rooms by means of special pipes placed in the thickness of the ceiling. In principle this installation should comprise a high pres-
sure fan of large capacity capable of supplying the quantity of pure air necessary (naturally the diameter would be calculated according to cubic capacity of the rooms to be ventilated); batteries of steam radiators for heating the air driven in by the fan (in winter for example); a humidifying chamber in which the air is charged with water vapour by contact with jets for pulverising the water arranged in the manner of baffle plates; a system of piping to distribute the humidified air through the rooms.

As has been seen above certain systems do not comprise distributing pipes.

All these systems, it should be remembered, create fairly considerable variations of temperature and humidity in different parts of the rooms, and produce draughts. This is why the installation of a humidifying ventilation system demands very careful study beforehand, and a perfect application of technical principles. Naturally the experts must decide the variations in method they introduce based on these simple data.

When, on the contrary, it is a question of premises already built and where nothing has been arranged for, special plant can be used including generally a pressure pump, pulverising jets and piping for bringing into the room the humidified air (atomisers).

The installation ought to assure a quantity of water in excess of that required to absorb all the calories given off in the shed. What happens is that a quantity of raw material goes into the shed where it undergoes one or more operations and is warmed or chilled according as the temperature of the room in question is higher or lower than that of the room in which the material has been previously treated. A quantity of heat can then be absorbed or given out; all this must be borne in mind in making the calculations.

The hygroscopic capacity of the material, its weight (kilograms per hour) must also be considered. The greater the less affinity of the textile material for water can be fairly well estimated by the amount which is taken up in conditioning as, for example, 8½ per cent. for cotton, 12 per cent. for linen and hemp, 18½ per cent. for combed wool, 17 for carded wool, 11 for silk, etc. Tables enable determinations to be made for calculating the quantity of water absorbed by a given textile placed in an atmosphere containing a given degree of humidity. Experts to-day can calculate exactly the renewal of air necessary, as well as the quantity of water which it is necessary to evaporate to obtain a given hygroscopic state and a given amount of air to be introduced.

The most important factors in the calculation are the maximum degree of humidity which the textile work can stand, the maximum temperature which can be allowed in the air of the room, the outside temperature and humidity in relation to the results to be obtained.

Details are given in the articles on textiles (cotton, wool, flax, etc.). So far as temperature is concerned it is admitted that the optimum is reached, with an outside shade temperature to the North and at 2 p.m., when at least 28° C. is recorded and a relative humidity of 45-50 per cent.

The technical expert is provided with formulas for calculating installations such as atomisers, saturators and vaporisers.

Neu gives in the following table the data for each type of installation according to the quantity of water to be evaporated and of air to be introduced to absorb 100,000 calories in a room in the inside of which it is desired to maintain a temperature of 28°C. and a relative humidity of 60 per cent., when the outside air is between 28° and 45° per cent.: 

<table>
<thead>
<tr>
<th>Type of machine</th>
<th>Calories to be absorbed</th>
<th>Outside air</th>
<th>Inside air</th>
<th>Quantity of water in kg.</th>
<th>Quantity of air in cu. m.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Temp.</td>
<td>Relative humidity</td>
<td>Temp.</td>
<td>Relative humidity</td>
</tr>
<tr>
<td>Saturators</td>
<td>100,000</td>
<td>28°</td>
<td>45 %</td>
<td>28°</td>
<td>60 %</td>
</tr>
<tr>
<td>Atomisers (3 grm. of water atomised per inc.)</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Vaporisers</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
</tbody>
</table>

These data permit of the following conclusions: "When an installation of atomisers is in question, the higher the state of humidity which can be maintained the less will be the number of changes of air required to maintain a temperature of 28°C. It will be sufficient to continue evaporation of the same quantity of water in the shed by passing a certain amount of air from the inside of the room into the apparatus. If the change of air is not limited, this type of plant will allow renewal to be obtained which will be dependent on the state of humidity, and the temperature of the room will fall making it possible to reach 24° to 25°C. with a relative humidity of 90 per cent., that of the external air standing at from 28° C. to 50 per cent. In the case of vaporisers similarly less air is needed to maintain a temperature of 28°C. with a relative humidity of 90 per cent. (Neu). On the other hand, when the air in the workshop is too humid and the steam and mist which form interfere with work being carried on and so affect output (see
the article "Air: Hot and Humid"), it is absolutely necessary to ensure desiccation of the air. For this object processes by means of hygroscopic substances (such as chloride of lime, magnesia, etc.) can only be effective in quite small rooms. In practice recourse is had to the following three methods:

(a) increase in the temperature of the surrounding air;
(b) removal of the steam by exhaust ventilation;
(c) ventilation with warm air.

(For details see article, "Air: Hot and Humid.")

CONTROL OF VENTILATION

Naturally it is right and useful to be able at any moment to control the general or local ventilation, if the objects in view are to be adequately attained.

The purity of the air can be determined by suitable analyses of the carbonic acid gas, the gases, the dusts, the temperature and humidity, etc. (See the articles, "Air: Diminished Pressure", "Air: Testing in Workshops", "Air: Hot and Humid", etc.)

The velocity of the air can be measured by anemometers or by the katathermometer.

The formulas established by L. Hill for his kata are the following:

(a) For velocities equal to or above 1 m. per second:

\[ v = \left( \frac{H - 0.13}{0.47} \right)^5 \]

(b) For velocities equal to or below 1 m. per second:

\[ v = \left( \frac{H - 0.20}{0.40} \right)^2 \]

where \( H \) is the loss in heat in milli-calories per second and per c.c., and \( \theta \) the difference between 36.5\(^\circ\) C. and the temperature of the room in degrees Centigrade.

The pressure of the air exhausted or driven in can be determined by manometers or suitable pneumometers (Krell and Prandtl apparatus, for instance).

When the room is ventilated mechanically, the standards of ventilation can be estimated by the output of the fan by means of the anemometer, which gives the average velocity of the draught at the point where the air enters or where it is exhausted.

Technical experts have determined certain objective standards (under the name of "constants") which are sometimes laid down in regulations.

Besides chemical constants (oxygen, carbonic acid gas percentage) there are physical constants to be thought of: temperature, humidity, cubic capacity of the rooms; rate of air renewal (the minimum standard would seem to be six changes per hour for sedentary workers, to be raised to ten for more active workers); velocity of circulation of the air (15 cm. to 1 m. for sedentary workers, 1 to 1.75 m. for semi-active, 1.75 to 5 m. per second for active work).

Biological standards must also be borne in mind in their bearing on the various sensations affecting the air of a room: the feeling of freshness, smell, closeness, etc. These various sensations, however, do not, by themselves, permit of a determination of the efficiency of a system of ventilation.

The ultimate basis on which physical and chemical standards of ventilation can be laid down must rest on the physiological results recorded.

LEGISLATION

See articles, "Air of Workroom," "Industrial Hygiene (Workshops)," "Cotton," "Wool," "Flax," etc.

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Vocational Guidance and Selection


The problem of vocational guidance and selection has occupied thoughtful men from the most remote times. Even in Plato's Republic, Socrates puts the question: "Should each person carry on, for all the others, the trade for which he is fitted; for example, should the husbandman provide the food of four persons, or should he, without considering others, devote a quarter of his time to seeking his food, and the remainder to building his house, and making his boots and clothing? It seems to me that the first method would be of the greater advantage to him." In this same dialogue it is said that things are done "better and more easily when a man only does work adapted to his capacity and at a time agreeable to him." In another dialogue, "Laws", the necessity for specialisation in requisite production is recognised, and it is there stated that "no ironworker works in wood; that no worker in wood is under the orders of workers of iron; and that each practises a single trade from which he derives his living". The idea of fitness perfected by specialisation is expressed by Xenophon in a somewhat uncertain manner when he states that "an individual whose work is confined to a speciality should of necessity excel in it".

In the Middle Ages the question of vocational guidance was considered from the doctor's point of view by Paul Zacchia, who studied carefully the aptitudes necessary for service as a monk.

In more recent times Pascal recognised that "the choice of an occupation is the most important thing in life", and Diderot added that "the man who is entirely fitted to his occupation, if he has genius, ought to be a prodigy; if he has not genius, unremitting application will raise him above mediocrity". Ramazzini also, in his classic work, has not neglected the medical aspect of vocational guidance.

It was not, however, until recent times, when mechanisation of industry has carried division of labour to an extreme degree, that the question of fitness and of the choice of a vocation has once more been forced upon attention and has demanded study by modern scientific means.

Vocational guidance of workers in industry has for its aim to recommend a vocation or a definite occupation to a man who possesses the necessary
fitness for the said vocation or the said occupation; on the other hand, vocational selection seeks, for a given occupation, the man possessing the fitness which makes him capable of carrying it on with success.

In 1906, in a short report submitted to the First Congress of Occupational Diseases, at Milan, De Giovanni dealt with the relations between these diseases and the personality of the worker, emphasising that the study of the human body, from the point of view of its structure, shape and functions, shows repeatedly great variety in types of structure and individual physiological variations. Hence arises the varying power of resistance shown by individuals to the same work and to various kinds of injuries which the work in question may cause. Preventive medicine should furnish advice to operatives as to the quality and quantity of work in relation to individual fitness, and should also show them how to increase as much as possible their output and prolong their working life. In fact, a great advance will be accomplished when the knowledge obtained suffices to fix, on a scientific basis, the criteria for determining the physical type of worker suited for any given occupation. De Giovanni says that only morphological, rather than anthropological, criteria can provide an adequate idea of how the functions of physiological correlation occur in an individual who is to be placed on a given kind of work.

There must then be considered procedure which, in the case of guidance, is applied in the interest of the worker and the factory; in the case of selection in the interest of the factory because, in the first place, what happens to workmen whose aptitudes do not fulfil the demands of the business is not taken into account. The employer arranges the work of selection so as to exclude the weak and inefficient, without concerning himself with the extent of this weakness or inefficiency. There are, however, experts who consider that after having satisfied the requirements of industry, which, at achieving increase of output, selection also contributes “to the happiness and success of the individual worker” (J. S. Rowntree).

Whether it is a case of guidance or selection, advantage is obvious as much for the management of the works, in reducing the number of useless workers and diminishing labour turnover or changes in the personnel of the works, as for the wage earner, who, from the fact that he is placed in a vocation for which he is well suited, finds his work to his taste and effects it with greater success.

In large concerns, where the posts are numerous and varied, vocational selection coincides, to some extent, with vocational guidance. Although confined to a limited sphere, it endeavours to satisfy, as far as possible, the needs of the working-class community. According to the National Industrial Conference Board, in 255 large American factories which have practised selection of their personnel for some years, no complaints are reported, beyond objections raised by individuals whose occupational fitness was below the average, either through disease or physical infirmity. But even for such persons, experience has shown that, placed in work which suits their physical condition, they may become useful and contented workers, representing a profit rather than a reduction in the output of the factory.

The importance of physical condition in relation to the output of work has been emphasised in the case of vocations calling not only for muscular efforts or for considerable bodily resistance, but also for psychological fitness. In the case of salesmen, for example, height and weight, according to H. A. Richmond, should be in proportion to their capacity for work.

Petrazzani and Patrizi, between 1907 and 1909, considered independently of each other the expediency of an examination into vocational aptitude in the selection of motor-drivers. This was the starting point for the numerous studies which have subsequently contributed to progress in this domain.

Selection is also regarded as a factor in the prevention of accidents, especially in countries where legislation makes the employer responsible for injuries sustained by the worker, or in the case of industries in which the work is particularly dangerous, such as railways and aviation.

The importance of personal aptitude in the production of accidents has been dwelt upon by a number of authors. Thus, for example, Stephenson found that diminution in the number of accidents sustained by apprentices did not depend solely on the degree of skill attained by the workers in proportion to their practice at their occupation, but also, in large part, on their innate manual dexterity. The figures showing the comparison between the frequency of accidents among competent and incompetent beginners were as 1 is to 1$\frac{1}{2}$, whilst they became as 1 is to 3$\frac{1}{4}$ for those two categories respectively at the end of their apprenticeship. This study showed that cer-
tain dispositions or aptitudes cannot be developed or perfected by exercise, and that it is necessary to select workers carefully before allowing them to engage in occupations for which they are not sufficiently suited.

By analysing some important figures on accidents to railwaymen, E. Schmidt found that 78.8 per cent. of cases occur to persons who have had previous accidents. This authority, like Pen, has emphasised that there is a predisposition to accidents which must be taken into account, especially in the case of work which is associated with risk.

This predisposition has also been studied by Eric Farmer and E. J. Chambers among sixty-four apprentices and forty workwomen. They noted the number of accidents which happened to these persons over a fairly long period, and included even insignificant wounds which required only a slight dressing. The results did not show any correlation between intelligence and a predisposition to accidents. On the contrary, accidents were found to be clearly associated with disordered or insufficient sensory-motor functions of kinesthetic co-ordination, or with temperamental derangement.

On the other hand, the same authorities were able to show a correlation between a predisposition to accidents and the individual's output capacity. This capacity was lower than the average in individuals placed on work for which they were unsuited; and these workers also sustained a larger number of accidents. These individuals had given less satisfactory results when submitted to an examination made by means of qualifying tests.

Vocational guidance and selection require a careful examination of the physical and mental constitution of each prospective worker, as well as an analysis of the vocation. In the first place, collaboration between the psychologist and the doctor is required. The psychologist, in the person of the school-master; who in reality is only a practitioner of psychology, must seek out psychological aptitudes; hence arises collaboration between the school and those interested in vocational guidance.

For physiological aptitudes, recourse must be had to the doctor, who is alone able to understand the functioning of the human body; and his habit of thinking biologically must be brought into play.

Efforts have sometimes been made to distinguish between the psychologist and the doctor, but at the present time such discussion is quite useless. Incomprehension of the pathological condition by the physiologist has also been claimed. In the present-day state of knowledge this is also a futile attitude, for physiology and pathology are interwoven, and it is impossible to understand one without the other.

Thus participation of the doctor in the work of occupational guidance is indispensable. But it is not provided for in the same way in all countries; only those of certain importance industrially — and in these chiefly a few large centres — have organised this collaboration and attained practical results.

The doctor, usually the school doctor, is generally called on to exercise his skill in the guidance offices, working in association with the employment exchange, where the vocational guidance expert centralises the information supplied by the school, the employment exchange and the doctor.

NATIONAL OFFICES FOR VOCATIONAL GUIDANCE

In Austria, the Vocational Guidance Office of Vienna has organised a medical service on systematic lines. The doctor gives his opinion for or against such or such occupation, gives advice as to hygiene, and directs the weak and sick to the public health offices and welfare centres for apprentices. Good organisation of the medical service has succeeded in attracting the attention of employers, and in several trades employers compel their young workers to pass a physical examination at the time of their engagement.

In Belgium, the Vocational Office of the Brussels district has every young man and young woman who desires advice on the choice of a vocation first of all medically examined and the result entered on a sheet drawn up by the medical officer of the Office (O. Decroly and A. Nyns).

In Czechoslovakia, the central office of the Vocational Guidance Organisation at Prague recommends a medical consultation at the time of choosing a vocation.

In France, collaboration between the employment exchange and the doctor exists, for in most of the Vocational Guidance Offices * the great majority of children are submitted to a careful medical examination; although attempts are still confined almost entirely to negative vocational guidance, yet there and there pathologic examination is beginning to be accorded to the fact that there are two kinds of contraindications: those which are absolute and those which are relative. The latter are susceptible of improvement, though this will only be attained by a better organisation of physical education, or the creation of centres for vocational re-education (Fontègne). The Lyons Office for Vocational Guidance and Employment has

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* Vocational Guidance Offices refer to the national or regional organizations responsible for providing guidance to the unemployed and assisting them in finding suitable employment.
have examined them from the viewpoint of choosing a vocation.

In Spain, the Vocational Office of Barcelona also attaches great importance to a medical examination for young persons who seek advice on the choice of an occupation.

In Switzerland, there is no general rule for collaboration with the doctor. Such collaboration is however at the present time very well organised at Berne, where the school doctor enters upon the guidance sheet the findings made during the examination of the scholars, there being a compulsory examination for all children during the final school year.

In the United States, collaboration with the doctor is comparatively limited, the employment exchange not making a direct appeal for his intervention. However, a committee of paediatricians and specialists in industrial hygiene, set up by the Children's Bureau, has formulated a number of recommendations regarding the question of fitness for work and the need for it to be dealt with by a medical officer nominated for this purpose.

In addition to these vocational guidance offices, a doctor may be called on to collaborate in the work of committees for vocational guidance. Up to the present, France is the only country where there exists such a national committee, a scientific section of which is "charged specially with the study of problems of a medical nature, physiological, psychological and hygienic, having a bearing on vocational guidance". On behalf of this committee Drs. Lauffer and G. Paul-Boncour furnished a report dealing with the type of vocational guidance sheet desirable (see Appendix to this article).

In some countries collaboration of the doctor in vocational guidance is laid down by law: France (Decree of 26 September, 1922), Germany (Order of the Federal Employment Exchange of 12 May 1923, etc.).

THE PRACTICE OF SELECTION

Measures have been taken in several countries to ensure a systematic method for vocational selection.

In France, a medical selection examination, such as is in force in several public and private concerns, is made a rule on the great railway systems. Some companies entrust this examination to medical specialists. In civil aviation, selection is very careful; particular importance is attached to a general medical examination, without, however, neglecting the special tests. The General Transport Company for the Paris district has the use of a private laboratory controlled by the municipal authorities, which is also intended for the examination of taxi and tram drivers; but the examination is confined to psychomotor reactions, and is in no way medical.

In Germany, it is practised in a large number of industrial firms and in the
transport industry. On the State Railways (Deutsche Reichsbahn) the method of selection was applied in the case of 13,000 apprentices in the repair workshops during the period 1921-1923. In the Berlin trams concern, the management have the employees examined as to their fitness for various duties. In 1926 requests were made by 267 large private concerns for the services of the offices of vocational selection. In all these cases particular attention was given to mental capacity, while a physiological examination, properly so called, when it did take place, was only carried out in a summary manner and as a preliminary.

In Great Britain, vocational selection sheets are in use in a very limited number of industries, and very often have only been elaborated in an empirical manner (E. L. Collis). This gap is to some extent filled by the work of the National Institute of Industrial Psychology of London, where attention is directed, among other matters, to the question of selection.

In Italy, selection is practised in some of the large public concerns, such as the State Railways and the trams, in which the employees are examined medically before engagement, in a manner calculated to ascertain whether they possess the capabilities required to perform a definite kind of work. As regards private industries, medical collaboration is provided for in the methods of selection in use.

In the United States, according to figures published in 1926 by the National Industrial Conference Board concerning industrial undertakings which submit their workers to a medical selection examination, the number of those refused work was negligible in the large works which afforded considerable opportunities of placing. On the other hand these refusals increased in undertakings characterised by advanced specialisation. The causes of refusal were chiefly the following: tuberculosis, venereal diseases, hernia, heart disease, monocular blindness, amputation of limbs, mental weakness, defective hearing, specific varicocele and hydrocele, infectious or contagious diseases, diseases of the kidneys, rheumatism, arteriosclerosis, chronic alcoholism and drug addiction.

A medical examination for the purpose of vocational guidance or occupational selection differs in no way from a general clinical examination. It is characterised solely by its object, and attention is directed to the fitness of an individual for a definite occupation or vocation. For this purpose the doctor should base his opinion on facts furnished by an analysis of the occupation.

The elaboration of an analysis of this kind consists in deciding on the different physical and psychological qualities required for carrying on with success the vocation under consideration. In this work it is of first importance to avoid increasing without limit the number of qualifications required, and to know how to distinguish between the essential and the accessory; every vocation presents a number of difficulties which are surmountable by any normal individual, whilst it is characterised by special difficulties which need special qualifications to overcome them. These latter are the difficulties which the technician, who knows the occupation, should have in view when he is drawing up a list of the essential qualities required (Bolt).

Satisfactory vocational monographs exist only for a very limited number of occupations, and agreement of views on this subject is entirely lacking. Divergencies of opinion abound directly any question is raised of the relative value of qualifications, and of the required degree of accomplishment or proficiency in regard to these (Bolt).

Whilst, for clinical observation, it suffices to follow a general procedure, it is otherwise when choice of an occupation is at stake. As a matter of fact, a description valid for one district may be without value for another, for the processes and characteristics of the same occupation may vary with place and circumstance. Hence the necessity for the local technician and the works doctor to supply particulars relating to the particular aspects of the occupations in the district from the point of view of the human factor. General principles can only be laid down, once for all, by taking as a starting point the element which remains invariable, namely, the human factor.

In England, the National Institute of Industrial Psychology, which supplies industries with vocational monographs on scientific lines, has studied vocation in the workshop, and has given detailed analysis of the mental and physical qualities which are required, chiefly: accuracy and rapidity of movement, attention to details, resistance to distraction and monotony, and accurate judgment of distances, shapes and colours.

In Germany, a bibliography of vocational monographs, which is relatively complete, has been published by the Bureau of Vocational Guidance of the Employment Exchange of the State of Saxe-Anhalt, in collaboration with the Federal Labour Office of the Reich.

In the United States, the large industries have, for some years, introduced into their programme of scientific organisation of labour the elaboration of vocational monographs ("job specification"), in which quite an important part is devoted to such physiological aptitudes as maxi-
mal limits and qualities preferred as regards age, sex, colour, height, weight, length of the limbs, power of lifting, power of grasp, lung capacity, vision, hearing and the degree of infirmity tolerated.

THE DOCTOR’S TASK

The general principles of vocational guidance, according to Fürst, should take into account the following considerations: (a) the general constitutional examination; (b) the examination of the systems of the body; and (c) the sensory organs.

(a) The General Constitutional Examination

Proportions of the body and anomalies in structure: relation between the length and breadth of the body. When this relation corresponds to the age of the individual, the latter will be regarded as biologically correct (Kaup’s law of body proportions). The relation “weight/height” being at a given age the same for individuals of different height, if there is a variation it can be deduced that some anomaly exists in the constitution. Considerable variations call for a thorough examination of the internal organs. The vital index — the relation between weight as numerator and height multiplied by the circumference as denominator — is based on a similar principle.

The general aspect of the individual must be taken into account. In fact, diseases of the thyroid due to excess of functioning (hyperthyroidism) are indicated by a tendency to acceleration of the pulse, with cardiac excitability and by exaggerated sensitivity to heat; such individuals should not, therefore, be advised to take up a vocation which exposes them to high temperatures. The thymic constitution, with hypertrophy of the thymus and of the lymphatic tissue, is characterised by an abnormal reaction to external influences such as electric currents; it constitutes a predisposition to death by electrocution; therefore persons with a thymic constitution are advised not to take up the career of electrician. Arthritis, or a predisposition to rheumatism, gout and renal affections, are contra-indications for occupations involving danger from cold. The asthenic type signifies a disposition to cardiac and pulmonary affections, and a dusty or sedentary occupation should not be recommended for such persons.

Some anomalies of growth, without organic disease properly so called, may be combated by such moderate stimulation of growth as mechanical work in the factory; whereas strong stimulation, such as the occupation of builder, blacksmith or butcher, would only aggravate the condition. Occupations which exert a bad influence on growth are those of harnen, hairdressers and tailors, occupations in the printing trade, and work requiring close attention.

(b) The Examination of the Systems of the Body

1. Osseous system. — (i) Vertebral column. Any predisposition to deformity of the vertebral column may be aggravated in the following occupations: office work, tailoring, work requiring great accuracy, and carpentry when working with the plane, if, in the periods of rest, adequate precautions are not taken. Considerable malformation accompanying general and habitual debility contra-indicates an occupation requiring general effort, such as carrying loads. The urine should be analysed when there is lordosis at standing occupations.

(ii) The thorax. — Slight rachitic malformations tend to disappear during the exercise of most occupations. More accentuated malformations are contra-indications to difficult work. Special attitudes may have an unfavourable effect on the development of the thorax; such are those adopted by tailors, workers on close work, like watchmaking and engraving, shoe-makers, carpenters and hairdressers.

(iii) Lower limbs. — Pronounced deformities of the lower limbs and flat foot constitute a hindrance to standing and walking occupations.

2. Respiratory system. — Obstruction to nasal breathing is a contra-indication for all dusty occupations. A history of chest trouble in the family or the individual is important, and calls for a radiological examination. If active tuberculosis is suspected, all hard work must be discouraged, and, if possible, there should be a period of recuperation before entering any occupation. Cases of marked tuberculosis with expectoration, even without bacilli, should be excluded from food industries and from workshops where dust is given off, or where a number of persons are at work. Slightly built individuals

1 Handwörterbuch der Arbeitswissenschaft, article "Berufs-Beratung (ärztliche)", Halle, 1927.
should be directed to open-air occupations and kept under medical supervision.

Asthmatic subjects should be dissuaded from the entering the occupation of glass blower, or from a musical career where wind instruments are concerned.

3. Circulatory system. — (i) Organic lesions are contra-indications for all occupations requiring muscular effort; in these cases sedentary and commercial occupations and most of the technical ones with close work are to be recommended.

(ii) The irritable heart, with Basedow's vasomotor disturbances, renders individuals unfit for occupations entailing great effort; on the other hand, work requiring little effort has generally a favourable effect. Night work, the alcohol and drink industries, and occupations exposing to high temperatures must be avoided.

(iii) Anaemic persons should be advised against hazardous occupations, with exposure to lead and deleterious gases or fumes; they should not work in dark workshops.

4. Abdominal and digestive organs. — Predisposition to gastric affections is a contra-indication to continuous work. Predisposition to dental caries is a contra-indication for the occupations of baker, confectioner and miller. Tendency to habitual constipation excludes from occupations which cause a compression of the abdominal organs. General asthenia, a tendency to enteroposition, hernia or cryptorchidia exclude occupations demanding great effort; renal disease is a contra-indication to work in the open air, due to cold.

5. Nervous system. — The general constitution ¹ must be taken into consideraion, including the torpid type with psychopathy or debility, the asthenic with depressed constitution or nervous excitability; microcephalus or hydrocephalus with debility; the stigmata of degeneration in the face and ears, or congenital malformations.

Psychopathic subjects and irascible and weak-willed persons should be detected, not so much with a view to deciding the kind of occupation they should follow, as on account of the necessity of supervision. Epilepsy is a contra-indication for the occupations of Slater, locomotive engine driver, chauffeur, erecter of machinery or cook.

6. Skin. — Chronic affections on the uncovered parts are a contra-indication for occupations concerned with food or in workshops where the personnel is numerous. Sweating of the hands excludes from fine work; dryness of the skin and a tendency to rhagades excludes from occupations where chemical agents are used. Here the general constitution is of importance.

(c) The Sensory Organs

1. Vision. — Stereoscopic vision is of such value that persons with vision in only one eye must be excluded from fine work as engravers or goldsmiths, and from the occupations of Slater, tinsmith and chauffeur.

² Fende insists on the importance of constitution in vocational guidance which he calls "biotypologic". The knowledge of this biotypology of the worker has for its object the recording of physical and psychic aptitudes, and of the capabilities and deficiencies of the individual in relation to standard efficiency, so that he may be employed in work which suits him best; the noting of morbid tendencies and constitutional weaknesses which may lead to diseases and accidents; the collecting for each individual of facts which may later on be useful for settling any medico-legal question which may arise in case of sickness or accident.

In addition to a human type physically and psychically normal, with a balanced character, Fende has described at least four abnormal types characterised by a want of balance in use of positions of the body, originating functions which create the tendency to definite diseases or accidents. Two of these types are characterised by excess of development of the length, compared with the breadth, of the body...
An examination of the best eye — the one most used — should be made. Sense of light: hemeralopia is a drawback to photographers, drivers and chauffeurs.

Sense of colours: minute examination is needed for the occupation of engine-driver, decorator or photographer. The seriousness of defects of refraction should be estimated according to the possibility of correcting them by spectacles.

Marked myopia excludes from needlework; a tendency to chronic conjunctivitis excludes from dusty occupations or those with a high temperature.

Visual acuity: at least two-thirds for each eye is required for all such fine work as that of opticians, watchmakers, goldsmiths, dentists, turners, printers, engine-drivers and postmen; two-thirds for moulders, sculptors, saddlers, shoemakers, fitters, chauffeurs, and chimney-sweeps, and at least two-thirds in one eye and one-third in the other for blacksmiths, tanners, bookbinders, bakers and agricultural workers.

2. Hearing. — Hereditary predisposition to otosclerosis is a contra-indication to such very noisy occupations as the iron trade, boiler-making, railway work, telephone work and the textile industry.

Chronic affections of the middle ear and affections of the rhinopharynx are contra-indications to occupations in which there is a risk of exposure to cold.

Central perforations of the drum are prejudicial for sailors, fishermen, teachers of swimming, and in some chemical industries.

Perfect hearing is required for the occupations of engine-driver, post office official, gamekeeper, forester, lorry-driver, as well as for commercial and administrative posts in which intercourse is required.

Vestibular examination is necessary in occupations which require a well-developed sense of equilibrium.

It may be added that Chajes collected in 1928, in the form of detailed tables, the hazards which are associated with various occupations, as well as the aptitudes which are required, and the contra-indications which must be considered, in the practice of rational vocational guidance.

APPENDIX

I. — MEDICAL SHEET FOR VOCATIONAL GUIDANCE PROPOSED BY DRS. LAUFER AND PAUL-BONCOUR AT THE NATIONAL COMMISSION OF VOCATIONAL GUIDANCE OF PARIS (DECEMBER 1926)

Date of examination:
Surname and Christian name of child:
Date of birth:
Address:
In Paris since:
Vocation desired:
Hereditary history:
Father (nationality and state of health):
Mother (nationality and state of health, pregnancy, confinement):
Collateral history:

Personal history:

Hygienic conditions of home:

Personal hygiene:

Medical examination

Height standing:
Height sitting:
Weight:
Type: facies, aesthenic, musculature, obesity or wasting.

Born at term? weight at birth? Infancy: walked at? talked at? Afflictions or illnesses: childhood: afflictions or illnesses; history of tuberculosis (glands, suppurations, fistula, pleurisy, haemoptysis). Ventilation and exposure to sun; humidity; crowding. Food; sleep; drink; use of tobacco; habits of cleanliness; sports; various excesses; former, recent or existing contact with infectious cases, and the duration of such contact.

Complementary examination

Relation of weight to height.
Puberty: onset, notation of development, condition of hairiness, menstruation.

Skin and scalp: sweating of hands and feet, eruptions or tendency to, sensitiveness.

Peripheral glands: cervical, at angle of jaw, submaxillary, axillary, inguinal.

The mouth:

Teeth and gums: state of dentition, state of gums.

Rhino-pharynx: coryzas (frequency); epistaxis (frequency); nasal permeability, complete or incomplete; state of pharynx, frequency of pharyngitis; tonsils; adenoids.

Larynx: affections; weakness.

Thorax and shoulder girdle: configuration; venous network; deformities.

Lungs, pleura and hila: affections; weaknesses; respiratory insufficiency; dyspnoea, signs of enlarged bronchial glands.

Heart and pericardium: affections; palpitations; arrhythmia.

Peripheral vessels: pulse; varicose veins or tendency to; disorders of the circulation of extremities.

Abdominal walls: musculature; abdomen fat, flat, hard; state of inguinal rings; hernias, deep abdominal palpitation.

Stomach: appetite; digestion; disorders of dyspeptic origin; vertigo, headaches, nonchalance, irritability, etc.

Intestines: intestinal affections; haemorrhoids.

Liver: hepatic disorders.

Osseous system and joints: bad attitudes; malformations, softness of bones.

Vertebral column: other affections.

Lims: shape of the hand; deformities or anomalies of the upper limbs; deformities or anomalies of the lower limbs; flat feet or tendency to; joints; joint joints.

Nervous system: various affections and nervous disorders; easy ejection; disorders of movement (paralysis), contracture, atrophy, trembling, agitation, tics onychophagia, spasms; sensibility (tendency to neuralgias and headaches); other affections.

Psychic disorders: emotional; very closely connected with organic changes; psychic and character anomalies.

Genito-urinary system; testicular ectopia; incontinence and disorders of micition; analysis of urine.

Thyroid and glands of internal secretion; hyperthyroidism.

Vision of each eye separately and binocularly; affections of the eye annexes; acuity and errors of refraction; colour blindness; the visual field. *

Hearing of each ear; the external ear, the middle ear, the internal ear.

Acuity:

Other peculiarities.

II. — TYPE OF A MEDICAL SELECTION SHEET

<table>
<thead>
<tr>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical examination</td>
</tr>
<tr>
<td>Physical constitution</td>
</tr>
<tr>
<td>Spirometry</td>
</tr>
<tr>
<td>Hands</td>
</tr>
<tr>
<td>Hernia</td>
</tr>
<tr>
<td>Hydrocele</td>
</tr>
<tr>
<td>Varicocele</td>
</tr>
<tr>
<td>Other lesions</td>
</tr>
</tbody>
</table>

Other anomalies.

Taste.

Development of dentition; dental stigmata.

Smell; dyspnoea of nasal origin.

Perimeter; expansion (xyphoidan); spirometry.

Respiratory rate; before exertion, after exertion; insufficient action of the diaphragm.

Consider irregular breathing which is physiological in the child.

Arterial pressure; rate of pulse after exercise; length of time to return to the normal; same investigation for arterial pressure.

Venous network, peritoneal tuberculosis.

Length of the arms (from middle of acromian extremity); from tip to tip; height of pubis.

Pupillary reflexes; other reflexes; disorders of co-ordination; sympathectomy, vagotomy.

Varicocele; hydrocele; atrophy; cyst of the cord; vesical affections; other defects; orthostatic albuminuria.

Other internal secreting glands.

Binocular vision (stereoscope, diploscope); sensitiveness to bright light; sensitiveness to prolonged application; acuity with bright light; acuity with shaded light; acuity in the dark (hemeralopia).

Sensitiveness to noise: continued, violent
Vocational Guidance

Psychotechnical examination

**Pulse**
Vision: Right eye  Left eye
Measurement of the eyes: 1  2  3  4

Test of simultaneous contacts
Index finger
Middle
Ring
Little

Estimate of surfaces: sight

Test of simultaneous movements of both hands

Dynamometer
Hands: (1) Right
(2) Right

Sweating of hands

Time of reaction

Ergograph

Tests of Toulouse and Pieron

Complex decisions

Arterial pressure

Baraesthesiometer

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Dr. A. Stocker
(Geneva).
Watch and Clock Makers


The watch and clock making industry has for its object the manufacture of mechanical apparatus of all kinds for measuring time.

The different kinds of work that are met with in the watch and clock industry are the following: foundry work, including rolling, cutting out, pressing and machine hammering; washing, degreasing, and pickling separate pieces, especially those intended for electro-plating; electro-plating, chrome-plating, lacquering with zapon, enamelling, countertracing, soldering, application of luminous paint; stone and glass work. Then comes an extensive field of work requiring great accuracy: adjusting, regulating, finishing and mounting.

The work may be carried on in workshops attached to large shops, and also in small shops which very often confine themselves to repair work.

The watch and clock industry tends more and more to concentrate the manufacture in the same works, instead of passing the watch from workshop to workshop. However, a large number of independent factories exist which are occupied in making separate pieces, such as hands, escapements and cases.

A large number of factories where chronometers are made — especially in countries which specialise in this industry — are equipped with workshops which can be regarded as models of their kind. But, just as often, work is carried on in some of the small shops, or in workrooms behind large shops, or, what is more common, at home; then it is under less favourable hygienic conditions. In fact, in Switzerland work is now very rarely done at home, and this custom tends to decrease more and more.

A watch and clock maker does his work in a sitting position with the head and upper part of the body bent forward; thus he is exposed to the evil of compression of the thorax and abdominal organs. Hence arises frequency of disorders of digestion which are increased by the absence of exercise in the open air.

Sources of Danger

Several injurious factors must be mentioned: dust is one, although it only arises in small quantities coming from filing or grinding such materials as gold, silver, steel, copper and brass. Dust may also arise from materials used in enamelling.

As regards gases, carbon monoxide must be noted, arising from foundry or blowpipe work, and also nitrous gases from pickling.

The preparation of separate pieces for plating, whether with gold, silver, nickel, or chromium, which includes the removal of grease and pickling, exposes the workmen to the action of hot and concentrated caustic alkalis, giving rise to eczemas and burns; to the action of nitrous fumes in pickling; of soda and soap during the washing of watch cases; and of trichlorethylene when the new method for washing cases and bodies is used. Although this operation may be done in closed apparatus, cases of poisoning have been observed, caused either by the faulty manipulation of the apparatus, or by the premature opening of the washing compartment, or during cleaning of the apparatus. Even with perfect management a slight escape of trichlorethylene fumes always occurs when the washing compartment is opened and the washed pieces are taken out (Steiner).

Electro-plating processes may cause exposure to the poisonous action of cyanides used in appreciable quantities in the preparation of baths for gold and silver plating. During hot gold plating fumes of cyanogen and hydrocyanic acid are given off, which should be removed by means of a good exhaust.

Chromium plating, which is coming to be used more and more in the watch and clock industry, is done by means of a solution of chromic acid at about 30 per cent. strength, used hot; the solution is very caustic and poisonous and easily causes eczemas and indolent ulcers. Irritant fumes are given off
from the baths; it is, therefore, necessary to provide a good exhaust.

Enamelling is being replaced more and more by "lacquering" (danger from resins, solvents, etc.).

The application to metal dial-plates of a kind of lacquer known as zapon, which is a solution of nitrocellulose in acetate of amy!l, is effected by means of sprays in front of an exhaust opening if the workshop is well arranged.

The lacquer is dissolved in vessels containing acetate of amy!l.

Painting with luminous paint sometimes causes in sensitive women an irritation of the skin of the fingers and even eczema.

It cannot be claimed that the list of occupational hazards in this industry is complete, owing to the great complexity of the industry, which is extremely specialised. In addition, a good deal of work is done at home, making it difficult to detect the injuries caused by it. Further, a large number of the factories or workshops are small concerns, and by no means lend themselves to the systematic application of prophylactic measures.

STATISTICS

Statistics relating to sickness among watch and clock makers are out of date and not very numerous. In 1896 at Frankfort-on-Maine out of 106 watch and clock makers and mechanics there were 71.3 sick, of whom 33.2 were incapacitated for work. At Vienna also the sickness rate was quite high, especially for the age-groups 21-25 years and 41-50 years. The highest figures were those due to tuberculosis and influenza.

According to the figures of the Local Sickness Office at Leipzig, the total number of days of sickness was not very high, whilst tuberculosis and forms of rheumatism were responsible for quite high figures. Nervous diseases were below the normal.

The English death-rate figures for 1921-1923 also show rates below the average. Respiratory diseases show very low figures, whilst suicide is fairly common.

PATHOLOGY

The occupational pathology of watch and clock makers is not very important. There exists a belief that the most characteristic disease of watch and clock makers is myopia, promoted by the bent position of the head during work. But the researches of specialists have not entirely confirmed this opinion. As a matter of fact, Cohn came to the conclusion that the watch and clock makers of Breslau, whom he carefully examined, were not more liable than persons belonging to other occupations where work demands close application. Whilst it is true that he found myopia in 9.7 per cent. of watch and clock makers, 4 per cent. of them were already myopes before joining the trade.

In this connection it should be remarked that myopes who can easily do fine work without any particular eyestrain readily choose the occupation of watch and clock maker. That this number of myopes is comparatively small — Emmert and Dor have found a proportion of 18 per cent. among printers — is explained by the fact that watch and clock makers constantly use for their fine and delicate work a magnifying lens applied to one eye, generally the right. In this way they avoid partly efforts of accommodation and efforts of convergence, especially when the worker can adopt the habit of keeping the other eye open. Lawrentieff, however found that the use of the magnifying lens encourages strabismus.

It is obvious that if the lighting of the workplace is not arranged according to correct principles, and if the worker has to adopt or has already adopted the bad habit of concentrating light on to the article worked upon by means of a globe of water, then in these cases eye-fatigue and even eyestrain may be found. Cohn has found this eyestrain in 10 per cent. of workmen examined.

In 1853 Delthil noted cramp of the right hand in a painter of watch dials, as soon as this workman took hold of the brush; and Cohn has given a very good description of spasm of the orbicularis muscle in watch and clock makers. This spasm would appear whenever the worker wanted to put a magnifying lens applied to one eye, and delicate work a magnifying lens applied to one eye, generally the right. In this way they avoid partly efforts of accommodation and efforts of convergence, especially when the worker can adopt the habit of keeping the other eye open. Lawrentieff, however found that the use of the magnifying lens encourages strabismus.

Further, a large number of the factories or workshops are small concerns, and by no means lend themselves to the systematic application of prophylactic measures.

It is obvious that if the lighting of the workplace is not arranged according to correct principles, and if the worker has to adopt or has already adopted the bad habit of concentrating light on to the article worked upon by means of a globe of water, then in these cases eye-fatigue and even eyestrain may be found. Cohn has found this eyestrain in 10 per cent. of workmen examined.

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Numerous cases of dermatitis (eczema), due to the use of lacquers, were recorded in 1930. For lesions caused by paint applied to dials to render them luminous, see article "Radium and Radio-active Substances".

According to Oppenheim and Neugebauer, watch makers who open watch cases by means of the right thumbnail have a short, hard nail twice as thick as the nails of other fingers. Finally, wounds of the fingers are to be noted, due to work at furnaces, or with milling and filing tools or presses; and also foreign bodies in the eyes due to dust particles of metal coming from lathes, milling machines and polishing wheels. However, hygienic measures for
the removal of dust are applied in most factories, and reduce these troubles to a minimum.

**Legislation**

Watch and clock makers’ workshops should satisfy the most exacting conditions of hygiene, and in particular those relating to ventilation and lighting, natural or artificial. Governments have sometimes wished to fix a minimum standard of lighting for watch and clock making; thus, for example, the Lighting Commission of the United States requires an average lighting of from 100 to 150 lux, with 50 as a minimum. The regulations made by the different American States — Pennsylvania, New Jersey, Oregon, Massachusetts and Wisconsin — have, in fact, adopted these standards. The English Departmental Committee on the lighting of workshops and factories recommends 30 lux for such fine work as manufacture and repair in the watch and clock trade, and 50 lux for very fine hand work.

Occupational cramp among watch and clock makers is compulsorily notifiable in the Netherlands.

**Bibliography**


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**Welding, Autogenous**

(Blowpipe Welding and Cutting, Electric Welding)


The object of autogenous welding is the permanent attachment of two pieces of the same metal by fusion or by softening the edges of contact by means of the local application of a powerful heat source with or without addition of metal of the same nature.

Whilst technically it is possible to include welding by forged iron, by soft steel, or by smelting broken or defective pieces (by reheating these in a mould by means of molten metal) under the designation “autogenous welding”, it must be remembered that the habit has arisen of applying this designation more especially to blowpipe welding, electric welding and aluminothermy.

**Technical Data**

Blowpipe welding is resorted to in many operations of metallic construction and repair, and in processes of refilling or building up where lack of material occurs, etc.

In the blowpipe oxygen serves as the combustion agent, and acetylene (oxy-acetylene blowpipe), hydrogen (oxy-hydric blowpipe) or lighting gas as the combustible. Methane, water gas (for certain special processes of manufacture), “blue” gas, oil gas, ethylene, benzene fumes or benzene, petrol and tetraline are also used. Similarly, compressed air is sometimes used instead of oxygen.

Acetylene, the flame of which attains a temperature of 3,600° C., is usually produced on the spot as required by starting from carbide of calcium, but gaseous acetylene (compressed or liquefied) is also used. At present liquid acetylene is kept in steel bottles containing about 30 litres filled with a porous substance containing acetone, or else is compressed at a pressure of about 15 atm. The porous substance prevents the formation of a vacuum in the bottle in which the acetylene might accumulate and give rise to explosion (see article “Acetylene”).

Hydrogen is obtained either by electrolysis or by starting from water gas by means of fractionated liquefaction and distillation. Lately it has been manufactured by starting from water gas and steam, causing these to pass over a contact mass of iron carried to a temperature of about 500° C., and with separation of the carbon dioxide likewise formed at the same time. The hydrogen is stored in steel bottles, where it is compressed to 150 atm., and thereafter placed on the market. Hydrogen given off as a by-product of certain chemical operations or prepared by means of zinc or hydrochloric or sulphuric acid is also used.

Oxygen is produced either by electrolysis or by liquefaction, starting with water, and is compressed to 150 atm. in steel bottles.

Electrolytic oxygen prepared by the Schmidt process contains, according to research engaged in by Bossard and Haeuptli, hydrogen in such large amounts that it produces a detonating mixture. It can however be obtained almost pure when made to pass through a special furnace constructed for this purpose.

Gas oil (Gas oil), obtained by starting with the gases from coke furnaces, is a mixture of ethane and ethylene, plus about 20 per cent. of acetylene.

The apparatus used for welding is the blowpipe, which receives the two gases used from small short pipes opening into the middle of the blowpipe in a mixing chamber. In front
WELDING, AUTOGENOUS

of this is situated an aperture with interchangeable jets.

When acetylene and oxygen are used, or lighting gas and oxygen, blowpipes with an injector are required, into which the oxygen is transmitted, at very high pressure, by means of an opening in the form of an injector, the second gas being aspirated at a weak pressure or without pressure and becoming mixed with the former.

In welding, the metallic parts joined are first of all prepared by planing, correction of faults and bevelling of edges, thereafter being placed in position and maintained there by screwing or other means (use of electromagnets). The two parts are thereafter heated by blowpipe, commencing at one end and continuing until the metal melts. When dealing with large articles, the point of contact is first, with metal, fine strips of the metal in question being used, one end of which is maintained in the zone of fusion, the liquid metal being then caused to fall in drops at the required points.

In autogenous welding with aluminium, the use at the same time of an agent of fusion capable of decomposing of the aluminium oxide formed is necessary.

Besides welding there is the process of rapid cutting with the oxyhydric or oxyacetylene blowpipe of iron and steel and more recently of cast iron.

Metal is brought to red heat with the point of the flame reaching the temperature of combustion of iron (1550°C.); the supply of hydrogen or acetylene is then cut off, leaving only a jet of pure oxygen under pressure. By successive alternation of this jet the required cutting operation is effected. In practice the same apparatus serves the two purposes, unifing the heating blowpipe and the cutting jet (oxygen), the two jets being either placed opposite each other or concentric. The blowpipe may be operated by a mechanical plant worked by hand or by a motor.

In cutting under water the jet of the blowpipe is covered with a bell, into which compressed air is driven at a pressure slightly superior to that at the working post. Before diving the diver lights the blowpipe, regulates the air pressure and then dives with the apparatus lit. Special lighters situated on the apparatus enable the diver to relight the blowpipe under water if it should be extinguished, without his being obliged to come up to the surface.

In cutting under water it is possible to use apparatus burning liquid combustibles (benzole, benzene, alcohol and benzole mixture).

Electric welding is effected in the same manner as arc welding or welding by means of resistance.

In arc welding the fusion of the metal may be obtained in various ways. The welding apparatus may be constituted by an arc lamp with inclined carbons and automatic regulation (Zenever process). The arc is directed downwards by means of an electro-magnet and the metal to be melted is placed in contact with the arc. This process has met with renewed popularity with the introduction of the hydrogen arc.

Usually the arc passes between the article to be welded, which constitutes an electrode, and an electrode made of carbon (Bernadas process) or a metallic electrode constituted for electro-magnet (process of Slavianoff) intended for building up. "Hydrogen arc" welding is based on the principle that electric discharge in an atmosphere of hydrogen makes it possible to attain a much more considerable temperature than in any other atmosphere and one which permits of the melting of all metals and even of quartz. The apparatus used is composed of two tungsten electrodes at an angle of about 60° and of a tube directed in accordance with their bisecting line, by which hydrogen or mixtures of hydrogen and nitrogen, lighting gas, water gas, etc., are supplied.

Welding by metallic electrodes may be applied for the same purposes as blowpipe welding and is of superior efficiency for renewal of worn pieces or for correcting defects in the dressing of castings. Electric welding is very much resorted to in metallic construction where it replaces with advantage riveting, notably in naval construction.

Welding by resistance (end to end welding; welding of points; continuous welding) is used for welding large articles. The articles to be welded are introduced into the secondary circuit of a transformer, through which a current of weak voltage and strong intensity is passed, thus raising the parts to be united to the required temperature and bringing them into close contact with one another. Usually these operations are effected in semi-automatic or completely automatic machines.

Finally, aluminothermy, consisting of the use of thermit, is resorted to in engineering, but only for urgent repairs or for certain types of work.
Thermit consists of a mixture of powdered aluminium oxide and iron oxide, which is placed in a special funnel packed round the fracture to be welded. Combustion gives off such great heat that the melted iron flows into the mould surrounding the pieces to be welded (welding of rails).

**Sources of Risk**

One of the risks connected with this work — and the one which is certainly the greatest encountered by welders and cutters — is that represented by burns.

These affect the naked parts of the body and especially the eyes, and are caused by flames of the burners, splashes of molten metal, ignition of gas escapes, rags or greased-soaked clothing under the action of the oxygen or are due to ignition and explosion of copper jets and pressure-reducing valves (formation of acetylde of copper with acetylene, super-pressure), etc.

Special mention should be made of *explosions* which may occur: explosion of bottles, formation of detonating mixtures in the burners as a result of defective regulation, etc. Explosions may be produced during welding or cutting of empty receptacles which have contained volatile products (benzene, benzol, etc.) or acids (notably sulphuric acid, in which case explosion occurs as the result of the action of the acid on the metal, or of fulminating gas).

Cases of poisoning may be caused by impurities contained in the gases used to form the point of the flame: arsenurried hydrogen where the hydrogen has been prepared from zinc and arseniferous acid; sulphurretted hydrogen, phosphoretted hydrogen or impurities in the acetylene (cases recorded by Brezina, 1920). The latter may contain phosphoretted hydrogen amounting to 0.04 per cent., which content represents not only danger for the workers but is also harmful as regards the mechanical properties of the welding material. When impure acetylene burns in an acetylene Bunsen burner, free phosphoretted hydrogen is present in the point of the flame and throughout the whole flame, disappearing only completely at its periphery. In the case of the oxyacetylene blowpipe, combustion of hydrogen phosphide occurs differently, the transformation into phosphoric dioxide is more complete and more rapid, and the quantity of free phosphoretted hydrogen becomes greater the nearer it is to the point of the flame. As in autogenous welding the point of the flame only is used, previous purification of the gas becomes essential.

In course of welding or cutting of lead, brass, brightened, zinc or articles containing these metals, cases of poisoning may also occur due to liberation of metallic fumes. Danger is generally to be anticipated in connection with lead or zinc fumes liberated during cutting of old zinc or old iron which has been previously painted with minium or lead colours, etc.

Dismantling of ships by blowpipe constitutes in this connection an important source of lead poisoning and of brass fever. In Germany, cases which occurred were so numerous that safety measures were imposed by a Circular dated 26 June 1923. In the United States, of 221 workers in the naval dockyard of Philadelphia, 112 cases of lead poisoning occurred between 1924 and 1925. In Great Britain, 131 cases occurred in 1924, one of which was fatal, and 121 cases between 1925 and 1929. In the U.S.S.R., 30 out of 56 welders in the naval dockyard of Leningrad presented signs of lead absorption, 5 signs of suspected lead poisoning and 7 of slight lead poisoning; 34 out of 70 in another dockyard suffered from lead poisoning. In a general manner, 75 per cent. of the cases of poisoning which occurred affected workers engaged entirely on board ship; 50 per cent. affected those who worked mainly on board and 25 per cent. those who worked on the quays (Silber, 1927).

These cases of poisoning are at times favoured in their development by particular working conditions, e.g., in enclosed apparatus, where gases of combustion, or those liberated by the residues of substances contained in the apparatus or by the metal, may occasion very serious injuries. In these cases the heat of the flame causes volatilisation of the residues still adhering to the sides of the receptacle, even in very small quantities and even after the receptacle has been cleaned and although the product in itself is not toxic. In fact, experience shows that in enclosed spaces the fumes liberated exercise such a serious effect on the respiratory system of the worker that though his work is subject to repeated interruptions he may at times be exposed to fatal risk (Fischer). Thus, for example, grey cast iron contains 3 to 4 per cent. of carbon in the form of graphite capable of combining with the oxygen of the blowpipe and producing carbon monoxide. This gas has often been the cause of fatal poisoning amongst welders (Holtzmann, 1928; Hegel, 1929; Schwartz,
Without imparting the luminous sensation, the invisible infrared rays, or calorific rays, are comprised between 760 and 1,500 μ (infra-red rays) and upwards to 50,000 μ. Whilst the former pass through the cornea, the crystalline lens and the anterior chamber in a weakened state and reach the retina without imparting the luminous sensation, the latter become absorbed by the anterior chamber, the conjunctiva and the cornea.

More important still is the series of the shortest invisible radiations, the ultra-violet rays with chemical action, whence their designation "chemical rays". They are comprised between 400 and 315 μ and even below. Those from 400 to 375 μ possess a triple action, producing partly and chiefly fluorescence of the crystalline lens and partly fluorescence likewise of the retina, while a third part probably arrive without undergoing change at the photo-sensitive elements of the retina.

The harmful action of the ultra-violet rays was referred to in 1904 by Hertel, and in 1908 Schanz and Stockhausen, as a result of experiment, formed the conclusion that these rays produced inflammation of the anterior part of the eye known in extreme forms under the names of "electric ophtalmia" and "snow blindness". They also exert, however, an action on the more deeply seated parts of the eye, producing notably intense fluorescence of the crystalline lens which, owing to its capacity for transforming invisible radiations of short wave length into visible rays, protects the retina. They are said further to constitute a cause of injuries of the choroid.

In electric welding the eye should be protected against the action of ultra-violet and infra-red rays and against...
glare. Though the temperature of the electric arc is estimated at 3,000 to 6,000°C, and gives a glaring white light, the calorific radiation during the action of the arc is so weak that at a distance of a metre the temperature only rises 2° C. in ten minutes. This elevation of temperature is due to the action of molten metal rather than to that of the arc. On the other hand, however, the ultra-violet rays have an intensity one hundred times greater than in the case of autogenous welding (Galanin).

According to this author, the intensity of radiant energy varies from 0.25 to 6.8 small calories per minute and per sq. cm. in autogenous welding, and from 0.25 to 13.7 small calories in electric welding. Demidowitch (in 1930), on the other hand, only met with values amounting to 7.2 small calories.

When the eyes are protected by a screen or by suitable glasses, control of the blowpipe and of welding operations demands a visual effort of some importance which it is necessary to take into account.

Holstein (1930) draws attention to the fact that electric welding is capable also of damage to the genital functions (alteration of the testicular tissue), but he adds that the existence of these troubles has not so far been clearly proved. He recalls finally danger due to the fact that the electric spark in passing through the air causes formation of nitric acid, and that welding may liberate acrolein fumes.

The temperature of the workplace may be relatively high where workrooms are badly ventilated, and still more so when the work is effected in enclosed spaces (boilers, piping, etc.), and where ventilation is difficult to install. Deutschmeister (1936) found temperatures reaching 35° C. in a boiler. It is obvious that the sensation of discomfort is all the greater since it is essential that the worker's face is kept close to the blowpipe. It may be said that the welder often works in a sort of individual nitch closed by a screen for protecting him against injury likely to be caused by the apparatus used by his fellow-workers. This method possesses, however, the inconvenience of offering obstacles to adequate ventilation of each working place.

The working posture may also constitute a source of injury or discomfort: often the worker is obliged to assume a cramped position, bent during 75 per cent. of the working shift (Demidowitch). Other postures are equally uncomfortable, the worker having to remain for hours on his side, with his back in a sitting posture, kneeling, etc. (Deutschmeister).

Mention should also be made of cutting under water, where the working posture is also very trying, since the worker has to exert a powerful effort in applying the blowpipe to the surfaces to be cut, usually encountering whilst doing so resistance from the current of water.

In conclusion, reference should be made to noise due to the blowpipe, especially where gas is used, or to other operations effected simultaneously in the workrooms.

**PATHOLOGY**

Apart from injuries due to burns and explosions, ocular injuries are the most frequent. According to Toulant (1925), ophthalmia due to autogenous welding is rare where the workers' eyes are protected by dark glasses, but may occur as a result of excessive susceptibility of the eyes or as a result of inadequate protection.

The acute form, constituting a type of kerato-conjunctivitis, is characterised by desquamation of the corneal epithelium. It presents the same symptoms as actinic ophthalmia (Toulant). Hirschberg (1898), Cruellitz (1906) and Snell (1909) have described an acute and painful ocular trouble caused by the electric arc, accompanied by watering of the eyes, photophobia, inflammation of the eyelids, with injury of the conjunctiva, the cornea and the retina. Apfelbach (1914) has recorded fifty cases which showed similar symptoms and more rarely forms of keratitis, retinitis, permanent pigmentary changes of the retina, and scotomas.

According to Bridge, the acute symptoms of electric ophthalmia generally appear four to eight hours after exposure, the duration of which may be counted in seconds ("a flash"). The duration of acute symptoms is dependent on the duration of exposure and the intensity of the arc. In general it does not exceed twenty-four to forty-eight hours, but ocular pain is very acute and almost insupportable during five to six hours. Swelling of the skin, a dry and harassing cough, and conjunctival irritation may last even for ten hours. The blinding sensation produced by the glare of molten metal lasts several days, during which time the worker is not able to fix or distinguish things and has the sensation of a black veil in front of his eyes.

Undoubtedly individual susceptibility plays a highly important role, and the symptom complex, being determined by the individual constitution, may vary very greatly. There is a certain rela-
tion, not however constant, between the phenomena produced and the intensity, the dimensions, the distance of the light source, and the duration of exposure of the eye to the action of the light. There are even known cases of ophthalmia affecting workers who have passed at a distance of 10 metres from an electric welding post, and who have only come in contact with the radiations indirectly or sidewise, so to speak.

Individuals whose nervous system is to some extent affected may also suffer from asthenopia, even in the case of very slight action of a lamp of medium intensity. Such individuals may even suffer from most serious nervous symptoms, attaining hysterical traumatism.

In conclusion, the various symptoms involved may be grouped under three classes: vascular or inflammatory injuries (injuries to the eyelids and the conjunctivae); functional injuries (dazzling, asthenopia, diminished sight, etc.) of a sensitive motor or secretory type, photophobia, pain in the eyeball, blepharospasm, derangement of the function of the extrinsic muscles of the eye, watering of the eyes, etc.).

Bridge has not met with the permanent injuries or cases of cataract mentioned by certain authorities. Apprentices are said to be more affected than experienced workers, probably due to the fact that they are less expert at employing means of protection.

The chronic form is characterised by diffuse scleritis (Toulant), owing to the combined action of luminous and calorific radiations.

According to Tacchini, this form is said to occur amongst workers engaged on autogenous welding with the oxy-acetylene flame after a few days' work, and is characterised by a sensation of fatigue, tension of the eyeballs, which are painful under pressure, and simultaneously by a sensation of dryness of the cornea and conjunctivae. The edges of the lids are red, and covered, especially at night, by a viscous secretion. The conjunctivae of the eyelids are inflamed, and the blood vessels very congested. In certain cases there is a perikeratic circle with injury of the iris. During work the fibres of sphincter pupillae are subjected to intense effort, hence marked myosis. After a certain time, exposure to light remaining the same, the myosis becomes less marked. At this moment more serious troubles set in. The retina, receiving less effective protection from the iris, suffers from the abnormal stimulation to which it is subjected, and shows persistent symptoms such as indistinct vision of objects, sensation of fatigue on regarding a light source, heaviness and headache, with a feeling of tension, at times attacks of intense headache, fatigue, nausea and vomiting. Ophthalmoscopic examination reveals a slight degree of injection of the papillary and retinal blood vessels. Cessation of work causes these symptoms to disappear, but the former resistance capacity of the visual sense is diminished, for a spell of blowpipe work is liable to cause immediate recurrence.

On the uncovered parts of the skin the ultra-violet rays of the electric arc exert a pigmentary action which may, in certain cases, develop into slight burning or intense "sunburn".

Amongst general troubles, there should be mentioned brassfounders' fever, due to the fumes of zinc liberated by welding zinced tin (Brezina), anorexia, frequent fits of vomiting during the night, symptoms triggered by a sensation of heat (Adler-Herzmark), and even pulmonary oedema (Kissinger, 1929).

The small quantities of nitrogen monoxide which are released from the elements of the arc, as well as particularly unfavourable condition (confined working space, bad ventilation, etc.) have been known to cause in six to ten hours serious phenomena among workers, characterised by breathing difficulties, spitting of blood and, even in the more serious cases after a period of apparent improvement, death in twenty-four to fifty hours. The inhalation of ammonia has been used as an antidote against nitrous fumes, bottles containing carbonate of ammonia being distributed to the workers.

**Hygiene**

Safety measures should be applied with a view to protecting the workers against the risks of explosion, burns and danger from the electric current. These measures are described in detail in most of the regulations issued in the various countries.

Workrooms should be well lighted and ventilated, with a view to preventing combustion gases, fumes and smoke liberated during welding from vitiating the atmosphere. Gas from the hearths utilised for preliminary heating of the articles to be welded should be captured and directed outside. In the production of hydrogen, zinc and sulphuric acid free from traces of arsenic and phosphorus should be used, and acetylene should be com-
plectly freed from impurities such as sulphuretted and phosphoretted hydrogen. Adequate precautions should be adopted where toxic or dangerous products are used (benzene, etc.), or in view of their possible content of carbon monoxide or methane. Work should be carried out in the open when it is not possible to provide adequate ventilation.

All welding or cutting of boilers or similar receptacles in which the presence of the flame may give rise to explosion of gaseous mixtures should only be engaged in subsequent to thorough cleaning and elimination of such gases by ventilation, neutralisation or filling with water. Closed receptacles should be pierced with care in a water-jet. Those which have contained toxic products should also receive thoright cleaning. Where mixing receptacles are handled, the lid as well as the stirring mechanism should be removed wherever possible.

Workers engaged on welding and cutting of closed receptacles should be provided with adequate air renewal from time to time. Combustion gases should be withdrawn by a powerful exhaust ventilator in a continuous manner by means of air outlets placed as near as possible to the bottom of the receptacle.

As regards work effected in the open (dismantling of ships), the workers should be so placed that the gases and fumes removed by the natural air current are withdrawn in the opposite direction.

Protection against burns due to flames or sparks should be provided by incombustible, or at least fireproof, garments, aprons, as well as by boots and gloves of leather or asbestos.

Welders should be provided with respiratory apparatus for protection against eventual poisoning where ventilation is inadequate. When compressed air is used, masks should be worn unless filtered compressed air is provided.

The face and eyes should be protected by means of screens and glasses. This protection is often assured by apparatus fitted to the blowpipe or to an electrode, or by screens held in the worker's hand. These means of protection may again, in imitation of certain types proposed for use against splashings and projections, take the form of casques fitted to the head, or even to the face. Protective appliances of this kind enable glasses to be changed in accordance with varying conditions of work. For further reference to glasses, see article "Goggles".

In practice, the problem demanding solution is as follows: how is it possible to arrest the passage of ultra-violet rays coming from the artificial light source?

It is essential in the first place to insist that the same means of protection should not be applied in regard to all eyes, since the factor "eye" takes precedence of the factor "glasses". It is, however, certain that cheap types of glasses are rarely satisfactory, and that it would be advisable to support the proposal made by the autogenous welding associations of introducing a "certificate of guarantee" for the glasses to be used.

The question of the most useful colour of glasses for protecting the eyes of welders is still under discussion. For greater detail on this subject, reference should be made to special studies on this question. Here mention will be confined to the fact that all green, red, yellow, amber, greenish yellow, or smoked glasses offer protection against ultra-violet rays for the eyes of workers engaged in autogenous welding. Yellow or greenish yellow glass possesses a maximum power of absorption against ultra-violet rays and red glass against infra-red rays. Green is said to possess a total power of absorption for ultra-violet rays and an almost total (95 per cent.) power of absorption for infra-red rays.

The glasses should be unbreakable, and should be replaced as soon as they have become darkened by spotting due to particles of metal projected. The glasses should be closed at the sides with a view to protecting the eyes against metallic splashings and reflected rays, which may affect the eye from a lateral direction. They should be well jointed at the bridge, and at the level of the glass should have a dead space sufficing to ensure good ventilation.

All glasses with parts made of material capable of becoming dirty and giving rise to infection should be eliminated. Glasses should be strictly confined to personal use, as cases of trachoma have in fact been known to be transmitted by glasses (Tacchini). The worker should besides receive adequate protection from injury likely to be caused by apparatus operated by his comrades. In certain workrooms each welder is surrounded by large screens, or works in an individual cabin closed on three sides, painted in a dark colour to absorb the light, the fourth side being closed by a black curtain. This method, however, presents the disadvantage of demanding
good ventilation, which it is difficult to obtain in practice.

Important progress has been made by the introduction of new technical methods involving the use of automatic welding apparatus. The processes are carried out in closed cabins provided with coloured glasses through which the workers are able to follow and regulate the work.

A permanent International Commission on Acetylene and Autogenous Welding deals at its periodical meetings with the various problems encountered in this industry, and the French Central Office has published a leaflet concerning the following preventive measures: compulsory obligation for proprietors of autogenous welding plant to place at the disposal of their workers an ointment for slight burns, as well as dressings necessary for first-aid or for treatment of burns with a view to avoiding inflammation; compulsory obligation for workers engaged in brass-welding or welding of other alloys containing copper to consume, during work or after work, milk to which a little bromide of potassium has been added, the quantity or dose being prescribed by a doctor consulted on this subject.

Preventive measures against the risk of poisoning by toxic fumes, especially lead and zinc fumes:

The attention of workers should be drawn to the precautions to be taken by means of tracts, lectures, posters, etc.

Arc welding is work which demands great attention, coolness and accuracy. The Belgian prevention associations have published leaflets containing a list of the precautions to be taken. Those adopted by the Belgian Association only are given here:

1. Never engage in welding without a screen or helmet. Test the glasses to see whether they are in good working condition and have them replaced if they show the least defect; no direct light should be able to traverse the edges of the glasses.

2. During work the wearing of shoes instead of boots is prohibited unless leggings are worn with them. The wearing of celluloid collars is likewise prohibited.

3. As a protection against sparks the special clothing and leather gloves with cuffs provided should be worn.

4. When removing slag with a hammer special glasses with clear glass should be worn.

5. Care should be taken to see that the working post is well isolated on all sides by fixed or movable screens before commencing work, in order to avoid inconvenience to workers in the immediate neighbourhood.

Legislation

Measures of protection for women and children as well as hygienic measures to be observed are mostly included in those dealing with safety.

In the U.S.S.R. an Order of 13 August 1930 enforces medical examination of welders prior to engagement for autogenous welding.

Compulsory notification is required in France for ocular affections caused by industrial heat and light sources. Conjunctivitis, optic neuritis and retinitis, ulcers of the cornea and conjunctive and poisoning by zinc oxide occurring during welding operations and autogenous cutting are subject to compulsory notification in the Netherlands.

Compensation for injury due to very intense light (foundry workers, sheet-iron workers) or to ultra-violet rays is provided in Bulgaria; for diseases due to radiant energy when the latter is particularly powerful in Finland; for forms of dermatitis and ocular injuries due to light and radiant heat in Mexico and Sweden; for conjunctivitis and retinitis in Manitoba; for injuries due to the constant action of radiant energy of great intensity (retinitis affecting metallurgical workers) in the U.S.S.R.; for conjunctivitis and other affections of the eyes caused by manipulation of substances at high temperatures in Japan. Legislation also provides for compensation in cases of poisoning due to welded metals (see each article).

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Welfare Workers


In most countries the origin of the appointment of welfare workers may be sought in the need felt by employers for providing their workers with someone capable of giving first-aid treatment in the absence of a doctor in cases of illness or accident. This tendency has been further strengthened by legislation in those countries where the employer has been rendered responsible for all accidents occurring to workers in course of their work as well as the sequelae of these — incapacity for work, invalidity — current experience having proved that immediate and well-applied treatment in such cases greatly diminishes the extent of loss occasioned both to the worker and to his employer.

It is at present difficult to furnish a precise definition of a factory welfare worker. It is obvious, however, that the tasks to be performed by this type of social worker cannot be entrusted to anyone lacking the requisite experience and training.

The occupation of welfare superintendent is generally considered as a female employment, and choice of staff is mostly influenced by the need for appointing women with maternal instincts and sufficient sensibility to fit them for a profession which demands a certain amount both of charity and devotion. It is probably with this idea in mind that one authority has stated that it seems impossible that a man could fulfil this function (L. Schmidt-Kehl). These qualities, however, ought to be accompanied by aptitude of an intellectual order and adequate training, for the days are past when employers were content with persons sufficiently willing but lacking in special training and skill (F. Swift-Wright).

Usually the employer requires that the welfare assistant should aid the factory surgeon in an intelligent manner and be of useful assistance to the heads of departments, the sanitary engineer and the administrative branch (statistics), or, in short, should co-operate actively with all branches of the factory. In addition to this the welfare supervisor is required to co-operate with public health officials.

Throughout all the functions which she exercises, the welfare worker must bear in mind her role as collaborator of the employer, and friend and comrade of the worker, and must never regard her task as that of a detective (F. Swift-Wright).

There is no fixed scheme of duties in accordance with which the welfare worker can organise her work. She must be able to adapt herself to conditions and to enter wholeheartedly into the life of the factory and that of the workers. She will be able to accomplish this by acquainting herself with the working conditions, the living conditions, the preferences and the needs of the workers, by making every effort to establish sympathetic contact with the staff, in sharing both the joys and sorrows of the workers. It is in this way only that confidence can be established and that the welfare worker may fulfill adequately the role which she is intended to fulfill, namely, that of an enlightened and wise helper, earnestly interested in the lot of the workers. Because of the fact that the life of the factory is constantly subject to change, it is eminently necessary that she should possess a marked faculty for adaptation to circumstances and a spirit of initiative, prompt to act in unforeseen circumstances (L. Schmidt-Kehl).

The welfare worker, still very often in the pioneer stage, will find that her field of action has no limit short of a thoroughly well-organised establishment. Most frequently, especially in a factory of secondary importance, such organisation is lacking, and the welfare worker is then left to her own devices as the one and only individual interested in hygienic and social conditions and industrial relations. The only limits to her activities are those imposed by the ideas of her employer or by her own strength, until she is able to determine the scope of her task and to establish its natural limits (F. Schmidt-Kehl).

It is nevertheless possible to enumerate amongst the numerous duties of the welfare worker a certain number
of clearly defined tasks. She must pay frequent and thorough visits to the workrooms in order to become acquainted at all moments with the situation of the workers as regards health and safety. She must enter into close contact with supervisors and foremen in order to receive notice of all details relative to defects in the technical or subsidiary plant to which their attention has been called in course of daily practice. She ought at the same time to interest herself in suggested improvements which they may make.

The welfare worker must, again, develop an interest in the moral attitude of the male and female employees, devoting quite special attention to the young persons of either sex. She ought to devote attention to their conduct in the workshop as well as in the canteens, club rooms, etc., always striving to gain their confidence by means of friendly advice and well-considered and impartial intervention, imposing at the same time her authority, without, however, any tendency to abuse such authority. The type of discipline which she will thus strive to establish will be modelled on the type of discipline peculiar to family life, and not that of the barracks-room.

In the ambulance room of the factory the welfare worker, in the absence of a nurse, should render useful service to the doctor. In the absence of the latter she may replace him in so far as the limits of her knowledge permit; first-aid in urgent cases, always, however, applying to a medical man for matters beyond the range of her capacity. It is further the duty of the welfare worker to inform the members of a worker's family in the case of accident or illness occurring during presence at the factory. She should act as a liaison agent and where necessary fulfil all requisite formalities required of workers by the sickness funds, institutes of hygiene and social prophylaxis, medical specialists, hospitals, sanatoria, etc.

The welfare worker must make a careful record of all her observations on a card index or other register, which represents ultimately the source of information which enables her to supply the doctor or the management with regular and accurate information as to cases.

It is highly desirable that the welfare worker should intervene during engagement of workers. She must get into touch with new arrivals, see their medical entry certificates and become acquainted with their personal situation and social conditions. More intimate contact will of necessity be established later, contact on which the welfare worker will be obliged to rely whenever an occasion occurs for bringing to bear her influence on the psychology of the worker.

Another point at which the activities of this agent may render useful service is during transfer of workers from one workshop to another, since in such circumstances information of a psycho-physiological order, which the welfare worker is in a position to supply, ought to be taken into consideration. This makes it possible to maintain or even to increase the efficiency of a transferred worker by entrusting him with a type of work adapted to his strength. Since decisions of this kind depend on heads of workshops and foremen, the welfare worker should make every effort to render intelligible to them any suggestions which she deems it useful to make, avoiding, of course, at the same time any tendency to encroach tactlessly on the sphere of influence of these representatives of the management.

Data relative to the personal and social conditions of workers in possession of the welfare worker will enable her to impose her views as regards equitable measures of procedure relative to dismissal of workers. She may also intervene in favour of retention of those workers who have families dependent on them, or, where it is essential to effect a reduction of staff, for instance, urge the dismissal of a woman worker who has children to look after and whose husband earns a wage sufficient to maintain the family. Similar intervention relative to family circumstances will likewise be useful whenever the management or committees in the establishment are engaged in making decisions relative to the granting of aid to indigent workers.

Another task not infrequently entrusted to the welfare worker is that of supervising the domestic economy of the establishment: directing the work of charwomen and cleaners; advising the kitchen and canteen management; dealing with the lay-out of the factories, etc. By such tasks, especially in small factories, the welfare worker eventually succeeds in creating for herself a sphere of influence which finally facilitates intervention in every sphere in which the enlightened advice of an energetic woman may make itself felt.

Very often she is also requested to collaborate in organising a factory library, lectures and all other recreative or educational activities connected with the worker's life.
Apart from these activities effected in the factory, the welfare worker is also required to visit the workers in their homes. This side of her work is of such importance as to make it impossible to conceive of a real factory welfare worker ignorant of the conditions of family life of the workers under her charge (L. Schmidt-Kehl). During these visits the welfare worker has an opportunity of getting acquainted with the conditions of the workers. She will further by this means manage to win their entire confidence, a confidence which the worker does not in general accord unless he is very sure that the interest shown in him is not limited entirely to his activity in the factory, where he very often suffers from a sense of overshadowing of his personality, and feels himself to be nothing more than a cog in the machinery employed.

Whether it is a question of treating a patient, or helping a woman during childbirth, or looking after an infant, or again of measures of industrial and social hygiene and prophylaxis (family tuberculosis), the welfare worker will not lack opportunities for rendering herself useful and exerting a most favorable influence. She must, however, avoid all tendency to become dictatorial and likewise observe scrupulously as one of her most sacred duties professional secrecy as regards every fact learned outside the factory without the consent of the worker. As regards compulsory notifications imposed by law, it is the task of the welfare worker to explain to the individual affected the social necessities which govern her action. It is by such methods of explanatory comment that she will be enabled at each moment to effect a highly useful task of social education.

**Material and Moral Conditions**

In most countries the welfare worker is appointed by the employer. This fact does not, however, imply that she should in any way be hampered in her activities, since this would be contrary to the interests of the employer, to whose advantage it is to improve the material and moral condition of his workers. It must, however, be admitted that the employer's attitude towards the activity of the welfare worker varies greatly from one factory to another. Though the majority of employers regard welfare workers as officials of obvious utility, others are still inclined to judge their work as a type of pure philanthropy. In all cases one condition is absolutely indispensable in regard to their activities and that is that they should enjoy the confidence of the employer, who must not regard them merely as agents to whom he transfers a part of his authority, but rather as persons called upon to fulfill a social function.

A proposal has been made to make factory welfare workers State officials but to do so would be to create a barrier between the welfare worker and the employer, since the latter would be inclined to consider her as an intrusion in his establishment and to oppose her frequently and even at times unwittingly in a spirit of passive resistance, thereby rendering ineffective all useful collaboration.

It is also of importance that a spirit of comradeship should be established between the welfare worker and the workers. Only too often workers are inclined to regard the welfare worker as an agent of the management and to interpret every attempt at social service due to the initiative of the latter as a piece of decorative philanthropy intended to mask a desire for profit (Abbe). It is up to the welfare worker herself, thanks to her qualities, her tact and her devotion to dissipate this atmosphere of mistrust and establish the cordial relations which are indispensable to a fruitful social effort.

At present the welfare worker is encountered as a general rule in all large industrial undertakings. In certain instances, in view of the multiple activities to be fulfilled, it is even the case that in larger establishments the activities accomplished in smaller factories by a single individual may have to be entrusted to a group of welfare workers. Many factories have adopted a system by which one welfare supervisor is appointed to direct the activities of nurses, first-aid workers and welfare workers engaged in social services, visiting nurses, etc.

The institution of welfare workers is encountered in its most highly developed form in the United States. An investigation carried out by the National Industrial Conference Board (1925), covering 501 establishments, shows these to have at their disposal 773 doctors within call, 152 male and 688 female certificated nurses, whilst 252 of the factories possess private facilities for visits to the workers' homes. Information relative to the work of nurses deals further with 499 establishments, classified in accordance with the size of their staff. From the table reproduced below, it is seen that the institution of nursing services is more frequent as the factories become larger...
and employ a greater number of workers, being very general in establishments employing 1,000 wage earners and upwards.

NURSES IN 499 UNITED STATES FactORIES, 1925

<table>
<thead>
<tr>
<th>Size of the establishment</th>
<th>Number of establishments under consideration</th>
<th>Attached to the establishment</th>
<th>Visiting nurses</th>
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<tbody>
<tr>
<td></td>
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<td>Male nurses</td>
<td>Female nurses</td>
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<td>Under 500 workers</td>
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<td>From 500 to 999</td>
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<td>From 2,000 to 4,999</td>
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<td>From 10,000 and upwards</td>
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<td>490</td>
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 proportion of nurses attached to the establishment in relation to the number of workers

<table>
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<th>Size of the establishment</th>
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1 One of these is a male nurse

According to an enquiry carried out by L. Tattershall (1930), 1,006 industrial and commercial establishments, employing a total of 1,946,554 workers, had 2,022 welfare workers, including 189 men and 1,833 women. The men were engaged generally in establishments where difficult work was effected or where very few women workers were employed (iron and steel industry). The staff of these social service departments is practically permanent, 4 per cent. only being employed for periods of broken time. More than three-fourths of the welfare workers worked under a doctor and more than 50 per cent. of the establishments employed welfare workers inside the factories and also for the purpose of visiting the workers' homes. In three-fifths of the establishments providing for visits to the workers' homes treatment was given to workers and their families.

In Great Britain the number of "social workers" has been estimated at about 1,000.

In Italy, according to the Ministry of Labour (1923), the facts relative to persons employed on work corresponding to that of the factory welfare worker are as follows: 673 establishments, not including those in Venetia (Venezia Giulia), with 321,194 workers gave employment to 341 male and 118 female nurses for first-aid work. The General Industrial Confederation summarises as follows the duties entrusted to individuals engaged in social service in factories: sending workers and members of their families to medical institutions (hospitals, sanatoria, etc.); sending workers or members of their families to specialists for examination or surgical treatment or radiographic examination, etc.; sending pregnant women to maternity institutions, etc.; sending adults and children to holiday camps (sea, mountains, etc.); furnishing advice as regards taxes, pensions and similar matters and obtaining for workers certificates delivered by public authorities, etc.; in short, intervening where necessary between the workers and all civil and military authorities, undertaking for them correspondence with foreign consulates, giving them advice as regards aspects of social legislation and assistance in problems of a moral or legal order, etc.

In Germany in 1925 the number of factory welfare workers (Fabrikpflegerinnen) amounted to 110, 84 of these being in Prussia, 9 in Wurttemberg, 7 in Bavaria and 6 in Saxony. In most cases there was only one welfare worker to each establishment, but in those of a certain importance this number was increased up to ten in the case of a Berlin factory. On the other hand, several small establishments were found to have grouped themselves together to employ in common one welfare supervisor, an example of this being the case of fourteen factories in Rhineland.

Whilst in the United States it is chiefly the metallurgical and engineering industries which occupy the greatest number of welfare workers, in Germany, as in Italy, it is the textile industries which head the list, followed by the metallurgical trades.

In general, it has not been found that it is those factories which employ the greatest number of women workers which engage welfare workers. In Germany, out of a total of 96 welfare workers, 58 worked in establishments which employed more male than female workers. As regards the proportion between the number of welfare workers and the total number of workers employed, it was found that the greater the number of workers em-
ployed the greater also was the number entrusted to the care of a single welfare worker (cf. American statistics in the above table).

It is interesting to note that in Germany it has been found that the number of occasions on which male workers have sought advice from the welfare worker is less than that on which advice has been sought by women workers (L. Schmidt-Kehl).

**Professional Training**

One condition essential to the satisfactory fulfilment of the functions of factory welfare workers is good professional training. The data available show that schools attended in the various cases have been fairly varied. Thus, 38 welfare workers out of 93 came from a women's college of social studies. Of these 38, 7 had in addition attended a special course for factory nurses. Two had worked for several years as ordinary nurses and only one had attended a normal school of domestic economy. Without entering further into detail, it is seen from these facts that the professional training of welfare workers is fairly heterogenous.

Though welfare workers have for the most part only followed an ordinary course of nursing, it is nevertheless of first importance that courses of this kind should be completed by further training relative to social work and social institutions.

At the present time the existing preparatory institutes for welfare workers or factory superintendents may be considered as satisfactory centres of occupational training. Their curriculum offers students the possibility of acquiring on which advice has been sought a knowledge of nursing, political and social economy and industrial legislation. It comprises further instruction relative to public and private educational institutions, to social insurance and welfare, to individual and collective hygiene, care of the sick or wounded, care of children, as well as lessons in practical psychology in its application to social life, a knowledge of statistics, classification of data, organisation and enquiries and office technique, etc. A curriculum of this kind enables future welfare workers and factory nurses to acquire during their training a fairly accurate idea of the work which they are called upon to effect during their career.

The duration of study is about two years, the second year being devoted to specialisation (welfare, child care, social insurance, etc.). The curriculum of the training centres (in Belgium, France, Great Britain, etc.) comprises generally the following subjects: occupational deontology, domestic economy, elements of technology, accident prevention, first-aid, individual and industrial hygiene, elements of industrial accountancy, keeping of records and card indexing, industrial and social legislation, social economy (industrial organisation, wages, etc.), etc.

In certain centres the students are obliged to serve an apprenticeship, which comprises the time spent as a worker in the factory and a further period of three months in an institution for factory welfare or as factory superintendent, as well as visits to a certain number of industrial establishments and welfare and insurance establishments.

In other countries where training centres do not exist, special courses of varying duration have been organised. Thus in Italy "health visitors," or factories, whose duties are similar to those of factory welfare workers, receive a course of instruction lasting three months and organised by the Central Medical Committee of the National Social Insurance Fund.

In conclusion, in order that the welfare worker may be enabled to maintain her intellectual equipment and her sense of professional duty at a high level, it is essential that efforts be made in the direction of continuing her education with a view to preventing moral slackness and the effects of automatic routine, in the case of the isolated welfare worker, removed from her cultural surroundings and often too exposed to influences of a detrimental environment, in the midst of which she must needs maintain her status. This objective might best be realised by the organisation of periodical courses of instruction, by reading of a professional periodical and especially by the existence of a professional organisation facilitating discussion of technical problems and providing a defence of the moral and material interests of the whole group of factory welfare workers.

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WHITE LEAD

White Lead


CHEMISTRY

White lead is a basic carbonate or hydrocarbonate of lead, of which the composition is not always the same, but can be represented by the formula 2 CO₂Pb₂+Pb(OH)₂ (corresponding to 86.32 per cent. of lead oxide (PbO), 11.36 per cent. of carbon dioxide and 2.32 per cent. of water). Carbonate of lead is found in nature in the form of cerussite (PbCO₃) and hydrocerussite, of which the formula is that given above.

White lead takes the form of a white, amorphous, heavy, insipid powder, insoluble in water and soluble in dilute nitric and acetic acids.

White lead blackens readily under the influence of hydrogen sulphide (present sometimes in the air) in consequence of conversion of the carbonate into black sulphide of lead. This constitutes, together with its toxicity, one of its principal disadvantages.

The qualities most appreciated in white lead are its great covering power and the perfect emulsion it makes in suspension resulting in the skin produced on the drying of the oil. Further, white lead is a dryer; and mixed with other pigments does not spoil the tint.

The commercial value of white lead varies according to the process of manufacture. Two principal kinds are placed on the market — soft white lead, ground with much water and then dried, and hard, i.e. white lead deprived of its moisture which can then contain acetate of lead. White lead is often mixed with white substances of less value, such as barium sulphate, gypsum, zinc oxide, lead sulphate, Kao'n, silica, chalk, etc.

Certain commercial mixtures have distinctive names, such as flake white, light white (blanc léger), white lead, Krems white, Venetian white (white lead and barium sulphate in equal parts), Hamburg (1 of white lead to 2 of barium sulphate), Dutch (1 of white lead and 3-4 of barium sulphate), etc. "Silver" white, obtained by precipitation a solution of lead acetate with sodium carbonate, is only employed for artistic painting. Pattison's white lead is only a basic chloride of lead prepared by mixing a boiling solution of chloride of lead with an equal quantity of saturated lime water.

METHODS OF MANUFACTURE AND THEIR HYGIENE

Of the numerous processes of manufacture of white lead only the most important will be described, grouped according as they start from metallic lead or lead in solution. It must be noted that though the methods of treatment and the apparatus used differ in different factories, this is rather of technical than of hygienic importance.

(a) Dutch or Stack Process

Metallic lead is subjected to the action of air charged with acetic acid vapour; tribasic lead acetate is formed which, under the influence of carbon dioxide given off by fermenting manure, becomes converted into white lead. This process comprises the following operations:

1. Melting and Casting of Lead. — The melting of the lead ingots takes place in pots placed in a reverberatory furnace and continually stirred. The metal is run into iron moulds, slightly inclined, and divided into 2 or 3 compartments by longitudinal walls. Thin strips about a metre in length are thus obtained.

Formerly strips rolled into spirals were used. These are now replaced by grids obtained by moulding. All these preliminary operations are now carried out mechanically: from the melting pot to the cutting of the lead strips or moulding of the grids. These latter fall as they are made on an endless chain which drops them on to a trolley.

Dangers. — Continual stirring of the lead during melting exposes the workmen to considerable heat and to the fumes which escape even if the ventilating hoods over the working doors draw well. Mechanical stirrers of simple construction, installed in certain factories, materially improve the conditions of work. Particles of lead which become detached from the strips and melting pots fall to the
ground and can easily get into the air, rendering it toxic. Removal of the dross from the surface of the lead during melting is also a source of danger.

**Hygiene.** — Melting should be done in a separate room and under a hood which, during casting, allows only of such an opening as is strictly necessary for the process; during all the other manipulations (re-melting the strips or grids) it should be completely closed. Workmen should have at their disposal means of limiting or hindering direct contact with the metal. Skimmings should be collected in a special air-tight receptacle or under water as in the case of slag.

2. **Carbonating the lead.** — This is carried out in stacks or in chambers built of masonry. A bed of horse dung or of tan of 30 to 40 cms. thickness is arranged for this purpose. Above are placed rows of earthenware pots containing a little dilute acetic acid or vinegar, or a mixture of vinegar and the yeast of beer. The perforated lead grids are placed on the pots. Where strips are used these are rolled into spirals and introduced into the pots, a rim preventing them reaching the bottom and so coming into contact with the acid. The whole is covered with boards, on the top of which exactly the same procedure is repeated several times.

One stack comprises numerous rows of pots and may contain 30 to 35,000 kgs. of lead and the proportion of lead converted into carbonate is from 40 per cent. to 60 per cent. After the lapse of 6 to 12 weeks, the perforated grids or strips are more or less completely changed into white lead. In this stage of the manufacture the risk of poisoning is great, as the work is carried out by hand and everything (implements, pots, dung, boards, grids, strips, etc.) is covered or contaminated with lead compounds.

**Hygiene.** — Organic matter should be chosen which does not give off unpleasant or injurious emanations. In Holland, as in Great Britain, for example, dung is replaced by tan; fermentation takes longer, but the white lead is a better white. The grids or strips and the dung should be removed without any dust, by watering as much as is necessary the grids (white beds) with a hosepipe and stand pipe installed in each stack. In watering the white beds, however, the white lead is not rendered sufficiently moist to prevent generation of dust when the workman, be he as careful as he can, lifts the corrosions to place them in a box.

3. **Screening or picking,** which consists in detaching the crusts of white lead from the lead which has remained unattacked, used to be done by hand with a wooden mallet. The operation is done now in an apparatus hermetically closed, sufficiently protecting the workman against the toxic dust given off during the operation.

**Hygiene.** — Picking and screening by hand should be prohibited. The picking should be done mechanically above troughs of water and under the action of pulverising machines (rollers) so arranged as to make the white lead fall into the vats. The closed apparatus should be provided with an effective exhaust and draught to prevent the lead dust escaping outside. The white lead, detached and ground, is carried into a bolting machine and eventually reaches a vat, while the grid passes to a special compartment. Grinding is done wet; simple guards protect the workmen from the splashes. The falling of white lead on the ground should be prevented as far as possible. Sieves should not be opened until all the dust has subsided, which can be facilitated, if necessary, by a jet of pulverised water or steam. If trolleys are not used corrosions should be carried in impermeable boxes avoiding any direct contact with the skin.

4. **Grinding, Drying, Crushing, etc.** — White lead is prepared in three forms: in flakes, in powder and ground in oil. Flake white lead is the direct product of the corrosion after passage through the rollers. White lead in powder is obtained by a series of highly dangerous operations, although closed automatic apparatus with effective exhaust is now used. These are grinding, sieving and packing or placing in sacks. Grinding the corrosions (wet) is effected in various ways notably by a series of horizontal mills disposed in stages (cascade system). The suspension of white lead passes successively from one mill to another with considerable splashing. The white lead, after it has left the mills, is placed in earthenware dishes which are loaded on to racks and introduced into the stoves or corridor driers. After drying, the contents of each dish are thrown down a covered-in shoot which carries them to a cylindrical grinder provided with a sifter or bolting machine; the white lead is passed through the barrel or sack fitted to the lower part of the shoot. All these operations are
carried out in apparatus hermetically closed and provided with an exhaust. The white lead in powder thus obtained is sold as such or ground in oil.

5. Grinding in Oil. — Incorporating the dry white lead in oil is done in a horizontal mixer, above which is an oil reservoir, the rate of discharge being regulated according to the desired density of the paint. The mass then passes through two cylindrical rolls and from there is transferred to barrels.

Actually, the majority of white lead works mix the pulp white lead directly with oil without previous drying and dry grinding.

Hygiene. — The following precautions should be observed: prohibition of entry into the stoves to take out the dishes before they have been properly ventilated and cooled. The stoves should have impermeable walls (smooth on the inside), and solid, even floors, capable of being easily cleaned either by water or vacuum. The Regulations of Great Britain require that every stove shall have one or more windows made to open and so placed as to admit of effectual through ventilation, that no dishes be placed on a rack more than 3 feet from the floor, and that no stove shall be entered for the purpose of drawing until the temperature has fallen to 70° F. or to a point not more than 10° F. above the temperature of the outside air.

Workmen employed in drawing the stoves ought not to be employed on more than two days a week. Generally speaking, all the processes, from removal of the corrosions to packing, are effected by mechanical means, as well as from one apparatus to another. Such apparatus should be installed in special rooms, and provided with metal air-tight covers; they should not be opened until all dust has subsided. If the bins in which the white lead is deposited can be emptied mechanically from the outside, entry inside should be prohibited. For grinding in oil in particular the following precautions should be observed: white lead in powder should be deposited in the hopper of the mixer in such a way as to prevent all escape of dust. The hopper should be surrounded by a hood connected with an exhaust maintaining a negative pressure inside. The mixing of dry white lead and oil and the preliminary grinding should be done in closed apparatus, from which the white lead in paste form should pass automatically to the cylindrical rolls. Packing also should be done in such a manner as to prevent the escape of dust.

German legislation, for example, prescribes that white lead shall not be pulvrised and mixed with oil except in pulp form, thus prohibiting mere moistening in these operations.

The working day for grinding and packing dry white lead should not exceed 5 to 6 hours, even if the workmen are employed in other departments for some part of the day.

Precautionary measures are necessary for avoiding the contamination of water in the subsoil (excepting public sewage) by liquids containing organic matter such as manure, or by waste water from the factory containing lead compounds in suspension or in solution.

(b) German Chamber Process

This consists in submitting metallic lead to the action of a mixture of air and acetic acid and carbon dioxide. White lead is obtained dry or wet. Although carried out in various ways, the process generally comprises the following operations:

1. Preparing the lead (little danger); melting it and running it into grids or long strips (see under (a) Dutch Process).

2. Carbonating the lead; transport into the oxidising chambers is effected by means of trolleys; the chambers are built of masonry divided into stages by a scaffolding of wooden beams supporting wooden laths on which to hang the strips of lead which are exposed simultaneously to the action of acetic acid vapour and carbon dioxide introduced from outside in special pipes. During this operation, which lasts from eight to ten weeks, the openings in the chamber (doors, windows, etc.) are hermetically closed and no one may enter. The white lead formed, which is deposited partly on the ground and remains partly suspended to the laths projecting from the scaffolding, is washed by means of a stream of water directed on the laths to cause it to fall down. The laths are then thrown to the ground and the whole is again well watered. The white lead suspension then runs into a tank at the side of the oxidising chamber, being driven there by a strong stream of water and shovels.

Hygiene. — The walls of the chambers should be constructed of smooth and impermeable material, and the latter should be provided with water
supply and hosepipe; the whole of the internal contents before and after the introduction of the materials should be kept moist. Entry should not be made till after complete cooling and thorough ventilation (which however must not proceed so far as to dry the white lead). Detachment of the white lead from the laths, beams, walls, etc., should, if possible, be effected by a powerful stream of water. The white lead in the chamber should be removed either by a stream of water or, in the wet state, by trolley (it should be noted, however, that the white lead does not absorb water well and that it is almost impossible to deprive the chamber of all dust and not find small quantities of dry white lead on the uprights of the frames). By thus using removal by water all manual work is avoided; metallic debris, which may get into the vat, is easily separated by difference in density or by screening.

Although the German system sensibly diminishes the danger of poisoning, all necessary precautions for the protection of the workers should be adopted. They should have suitable boots; night work in the chambers should be prohibited; duration of work in filling and emptying should be limited to a maximum of six hours daily, with a rest of one hour after each spell of two hours’ work.

3. Washing, Grinding, Crushing, etc. — The suspension of white lead, treated with water in special washers, passes into vats provided with strainers where it loses a great part of its water; what remains is next removed by means of filter presses. The succeeding operations are the same as in the Dutch process.

Hygiene. — The measures to be observed are in general the same as those already indicated. The white lead should be conveyed to the washbecks by mechanical means or by a stream of water. Workrooms should be built so that no dust or lead fumes can enter. Workrooms in which the processes of dry sieving, packing, etc., are done should be separated from others by impermeable walls, if these operations are done while the product is in a dry state. If the dust cannot be immediately and completely removed by exhaust draught, other effective means may have to be devised as a pit alarm (respirators, moist sponges, etc.). Lastly, hours of work may be shortened. We give below a brief summary of the other processes most commonly applied.

(c) The French Process Known as the Clichy Process

This uses, as the initial material, litharge (see that article) dissolved in acetic acid so as to form a solution of the basic acetate, which is then precipitated by carbon dioxide. The operation is carried through almost entirely in the same apparatus. Litharge in powder is introduced into a tarred wooden vat containing dilute cold acetic acid provided with a mechanical stirrer. After having been clarified by decantation, the liquid passes into a precipitating vat where, through a series of vertical tubes dipping into the liquid, the carbon dioxide previously washed is passed. The white lead is entirely precipitated in 12 hours, and the residual liquor, which contains neutral acetate of lead, is used to dissolve a fresh quantity of litharge. Subsequent processes are analogous to those of the Dutch process.

(d) The Wulze (or Carter or American) Process

This method is very quick and less unhealthy than the others, but it requires a larger number of workers. Basic acetate of lead is obtained by causing acetic acid and a little steam to act on metallic lead in a fine state of subdivision and in the presence of compressed air. The solution of basic acetate of lead thus produced is treated in a carbonator with carbon dioxide under pressure. The transformation of the acetate into carbonate takes only from two to three hours.

(e) The Austrian Process

This is a modification of the German process in which fine lead leaves folded in the middle are used together with a hot liquid fermented by means of inferior dry grapes or fruit must. The reaction takes five weeks. The white lead put on the market in the form of thimbles or tiny hats sometimes underwent a superficial polishing — very dangerous as it was done by hand and had naturally to be done dry.

(f) The Electrolytic Process

This is excellent from the hygienic point of view, but does not appear to have yielded sufficiently good results either from the point of view of quality (poor covering power) or from the economic point of view. Among the different ways in which this process is applied, the commonest is the electrolysis of a bath containing a
soluble salt (acetate or nitrate of soda or ammonium) with one anode constituted by a plate of lead. The lead is changed into a basic salt and the carbon dioxide given off precipitates the white lead.

(g) A Process Without Acetic Acid

This process consists in using finely divided lead, carbon dioxide, air and water.

The Milner and James processes are only modifications of those described above. Lastly, a fairly unhealthy process has been described in which the lead is melted and oxidised in a current of pulvcrised steam. The litharge thus obtained is spread out on a floor and sprinkled several times with acetic acid, being stirred at the same time. The whole is placed in stoves heated until deisiccation and the reaction is complete.

USES

White lead is certainly one of the substances with the widest technical use in industry. It should be observed that, if, on the one hand, less poisonous or harmless substitutes have taken its place in many industries (to the number of 18) enumerated by Layet, it is, on the other hand, now used in work where it was not used before.

White lead serves above all as a pigment, either for white colours or for other light tints. It is thus used in the following processes: manufacture of satined, damasked, glazed (coated) paper, cardboard or paper for cards (visiting cards, wallpaper, etc.); in pottery, ceramics, enamels, stained glass, etc. (see these articles); in the glazed leather and waxed cloth industries; in the lace trade; in the manufacture of carpets; in the chemical industry (lead compounds). White lead is further used in the dressing of stuffs, whitening unbleached lace, gloves and shoes; as a pouce for reproducing designs on materials; for the preparation of the white paste for setting pearls; for paints and cosmetics (used since Roman times and still to-day in certain oriental countries). Mention should be made of cases of poisoning of alimentary origin (burning wood painted with white lead in bakers' ovens).

The commonest and best known use of white lead is, however, certainly as a pigment for water or oil colours in house painting, painting of wagons, ships, wood and metal work, decoration, toys, etc.; as a lacquer and cement for jointing, piping, etc.

At one period the use of white lead was very extensive because of a "white fashion" not only in furniture, but also in articles of wear (shoes, sticks, etc.).

TOXICITY — CHANNELS OF ABSORPTION, ETC.

[See articles "Lead (Poisoning by)"] and "Occupational Poisonings"]

So far as white lead is concerned, few examples of fatal poisoning by a single dose can be adduced (sometimes it has been 25 grm, and sometimes 40 to 45 grmrn.). The toxic dose varies according to individual and accidental circumstances. There are cases in which much smaller doses of salts of lead have shown themselves poisonous.

Although authorities agree that white and red lead are the lead compounds which cause incomparably the largest number of cases of chronic plumbism, they do not state what is the minimal dose capable of inducing chronic lead poisoning. It is thought, however, that though this dose is very often difficult or impossible to determine, yet a minimal dose of 2 milligrammes absorbed daily would suffice to cause chronic poisoning (Legge and Goodby).

Numerous analyses of the air in white lead factories made by Lehmann (1921) proved that one cubic metre of air contains 0.2-4 mg. of lead, which in a working day of 8 hours would represent the inhalation of 0.4-16 mg. of lead (on the supposition that a workman breathes during this time 1 to 4 cubic metres of air). Certainly, some of the lead is deposited on the nasal mucous membrane and is eliminated by the handkerchief. Kranenburg (Netherlands) in 1914 found in different departments of white lead factories in 1 cm. of air the following amounts: Chambers during emptying, 8 mg.; during emptying wet, 4-8 mg.; the same when very wet, 0.6 mg.; during the filling of the chambers, 3-2 mg.; stoves during emptying, 1.2 mg.; during filling 1.5 mg.

Examining the faeces of 9 white lead workers exposed to a moderate amount of risk, Lehmann found (1921) lead to an extent varying from a minimum of 0.1 mg. to a maximum of 1.8 mg. (average 0.9 mg.). He considered that these quantities can be regarded as inoffensive.

STATISTICS

Though statistics as to incidence of lead poisoning among workpeople in white
lead works are very numerous, many of them unfortunately date back to a time when preventive measures hardly existed and methods were very different from those adopted in modern factories. Statutory requirements also have materially modified the conditions under which the work is done and the data available from factory inspectors’ reports generally vary very much according as to whether the date precedes or follows the date of the application of statutory regulations.

Austria. — Before regulations were enforced (1894-1900) the general morbidity of white lead workers showed very high rates (105.3, 138, 247 and even 376.3 per cent. of the workmen in a group of four factories), as well as morbidity from lead poisoning (19.3, 56.4, 90.5 and even 135.6 per 100 workmen; but after they came into force the rates fell to 14.5 per cent. for general morbidity (e.g. at Klagenfurt, 1914) and to 9.4 per cent. for lead poisoning.

France. — The following figures are taken from a personal enquiry by Audisteré (of Paris) on the personnel of a white lead and red lead factory, with about 127 workers (of whom 47 were employed on white and 21 on red lead). Of the 47 white lead workers, the duration of employment in 12 cases had been 1 year, in 15 from 1 to 5, in 2 from 5 to 10, in 11 from 11 to 20, and in 7 more than 20 years. Cases of sickness of every description (lead poisoning and others) reported during the period 1918 to 1920 were as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Total working days</th>
<th>Total days of sickness</th>
<th>Ratio of days of sickness to days of work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918</td>
<td>34,320</td>
<td>2,530</td>
<td>12.4%</td>
</tr>
<tr>
<td>1919</td>
<td>30,300</td>
<td>2,900</td>
<td>6.9%</td>
</tr>
<tr>
<td>1920</td>
<td>42,500</td>
<td>4,350</td>
<td>5.1%</td>
</tr>
</tbody>
</table>

In 1922 (Regulations applied in 1919), the cases of lead poisoning in white lead workers numbered 94 (out of 797 reported cases). For white lead (and red lead), the figures are: 1925, 125; 1926, 105; 1927, 37; 1928, 31, 1929, 25; 1930, 44.

Great Britain. — The reports of the Medical Inspector of Factories show the following cases of lead poisoning in the white lead (and red lead) industry for the years 1925 to 1932: 1925, 19 (1); 1926, 13 (1); 1927, 11 (1); 1928, 21 (1); 1929, 9 (1); 1930, 3 (1); 1931, 1 (1); 1932, 4 (1), figures in brackets being the fatal cases.

In a memorandum on industrial lead poisoning issued by the Factory Department of the Home Office (1921), the number of cases per 1,000 workers exposed to risk was approximately for the years 1911-1914 as follows:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Approximate number of workers</th>
<th>Number of cases of lead poisoning per 1,000 persons employed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1913</td>
<td>1914</td>
</tr>
<tr>
<td>White lead</td>
<td>1,991</td>
<td>1,119</td>
</tr>
<tr>
<td>Vitreous enamelling</td>
<td>933</td>
<td>768</td>
</tr>
<tr>
<td>Tin-plate</td>
<td>878</td>
<td>406</td>
</tr>
<tr>
<td>Electric Accumulators</td>
<td>1,475</td>
<td>1,543</td>
</tr>
<tr>
<td>Paints and colours</td>
<td>1,490</td>
<td>1,227</td>
</tr>
<tr>
<td>Pottery</td>
<td>7,585</td>
<td>4,661</td>
</tr>
<tr>
<td>Smelting of metals</td>
<td>9,878</td>
<td>2,937</td>
</tr>
<tr>
<td>Coach painting</td>
<td>99,308</td>
<td>99,308</td>
</tr>
<tr>
<td>File cutting</td>
<td>5,556</td>
<td>5,556</td>
</tr>
<tr>
<td>Printing</td>
<td>58,777</td>
<td>58,777</td>
</tr>
</tbody>
</table>

It must however be remembered that, as in the case of white lead, diseases, the cases notified do not accurately reflect the situation, for without doubt there exist a certain number of cases latent or not recognised or omitted and therefore not included in the reports (quoted from memorandum).

Germany. — Statistics for the whole Empire cannot be given. In the factory inspector's reports information is given on the sanitary conditions of particular factories, which may serve as an indication.

In 1919 in a white lead factory in Prussia 37 cases of sickness per 100 workmen were reported (there were 10.9 cases in 1913) and 3.7 cases of lead poisoning per 100 workmen (2.7 per cent. in 1913).

In 1920 to 1921 Lehmann saw 400 workmen employed in 21 white lead works (of which 19 produced only white lead), and made the following clinical observations: no blue line in 53 per cent.; normal punctate basophilia in 24 per cent. and almost normal in the other 29—total 48 per cent.; haemoglobin normal in 64 per cent.; haematoporphyrine (in the urine) normal in 80 per cent.; strength of the extensors of the wrist normal in 56 per cent., and above it in 21 per cent.—total 79 per cent. The figures for morbidity in the German white lead industry per 100 workmen were as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Total working days</th>
<th>Total days of sickness</th>
<th>Ratio of days of sickness to days of work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1912-1914</td>
<td>42,500</td>
<td>2,900</td>
<td>4.9%</td>
</tr>
<tr>
<td>1915-1916</td>
<td>42,500</td>
<td>3,100</td>
<td>4.3%</td>
</tr>
<tr>
<td>1917-1919</td>
<td>42,500</td>
<td>3,500</td>
<td>4.4%</td>
</tr>
</tbody>
</table>

1 See for example the statistics given by Geism: Thesi (Zurich, 1911), pp. 72 et seq.
factories before coming into force in 1914. Stricter regulations were enacted in 1920 (27 January).

Italy. — No information save the results of the enquiry in 1912 by Rubino relating to 17 of the 35 workers employed in the two white lead factories of Genoa.

Netherlands. — Enquiry in 1912 by the Medical Inspector of Factories showed that among 98 out of 110 workmen employed on the average in 4 white lead factories, 83 gave evidence of lead in the feces. In 1913, 31 cases of lead poisoning among the 385 workmen in 4 white lead works were reported and similarly, in 1914, 28 of the 54 reported cases of lead poisoning occurred in the same four factories. During the latter years, the whole of the personnel was examined, with the result that a blue line was found present in 54; tremor of the fingers in 88; in one case paralysis of the fingers of both hands: 13 had had lead colic. The turnover among the workers was very high. In 1912, for example, the white lead works with an average of 110 workers engaged 354 persons.

Of the 23 reported cases in 1915, 14 related to 13 white lead workers in the factories in question. Of the 27 examined, only 26 showed a blue line and 52 tremor of the fingers. In 1916, 7 of the 23 reported cases were white lead workers. Following on these enquiries, the inspectorate decided from 1 January 1917 to limit the daily hours of work to 8.

In 1917 the reported cases numbered only 11, of which four were employed in the four white lead works. The periodic examination of 127 workers showed 43 with a blue line, and tremor in 60. In 1918 only one case of lead poisoning affecting a white lead worker was reported. The factories were reduced to 3, and 77 of a total of 110 workers were examined. A blue line was found in 13 and tremor in 22. In 1919, examination of 58 men was made of whom 26 were employed before 1919 and the remainder only since 1 January. The turnover was still very high.

**Pathology — Diagnosis**

**Demonstration of Lead, etc.**

[See article "Lead Poisoning"]

**Hygiene**

In addition to the special hygienic measures described in the paragraphs concerning the manufacture of white lead, the hygienic and prophylactic measures applying to the industry as a whole are identical and may be summarized thus:

The rooms should be spacious, well ventilated, with direct and sufficient daylight; the machines should be installed on a definite plan. The floors should be impervious, smooth and solid, and maintained in good condition. Workrooms should be cleaned daily by a stream of water as soon as work has ceased for the day. All trolley lines and drains should be cleaned carefully every day at the end of the day's work.

The walls and woodwork, etc., and generally all places where lead dust can collect, should be washed every week. All dry cleaning should be prohibited. The German regulations, however, permit of vacuum cleaning, even by means of portable apparatus. The dust then collected should be disposed of in a place suitably chosen, so that its re-entry into the workroom or absorption by the workers is impossible.

The walls should be smooth, impervious and lime-washed at least twice a year, or if oil painted or covered with a washable material, they should be washed at least twice a year.

The furnaces, apparatus, pipes, trolleys and all the objects which the workmen are called on to manipulate should be cleaned whenever necessary and at least once every fortnight. The handles of the tools (spades, shovels) should be cleaned every day after work has ceased.

Smoking, chewing and taking snuff during work should be prohibited as well as the bringing of food or alcoholic drinks into the workrooms.

Workers who have to manipulate lead compounds should be instructed as to the dangers to health of lead and as to the precautions necessary for guarding against them. This instruction should be given to every workman by the appointed surgeon on first employment and repeated at the periodic examination. Work in a white lead factory does not demand an apprenticeship nor any special aptitude. This explains why the personnel increases rapidly at certain periods of the year (when orders are good) to diminish rapidly afterwards. This turnover, which is constant and well marked, is characteristic of the white lead industry.

The happy effect of alternation of work in the factory with that on allotments close to it has been repeatedly noted.

**Legislation**

**Employment of women and young persons.** — It should suffice to say that legislation in general prohibits the employment of women in processes in the manufacture of white lead and of lead colours. Thus, for example, Argentina, Australia, Belgium, Canada, Czechoslovakia, France, Germany, Great Britain, Japan, New Zealand, the Netherlands, Poland, South Africa, and Switzerland exclude women
and young persons from "all work exposing the persons employed to serious risk of poisoning."

The First General Conference of the International Labour Organisation of the League of Nations (Washington, 1919) recommends that in view of the danger involved to the function of maternity and to the health and well-being of the offspring, women and young persons under the age of eighteen years be excluded from employment on the manufacture of white lead and on cleaning workrooms where such work is effected.

It is further recommended that the employment of women and young persons under the age of eighteen years in processes involving the use of lead compounds be permitted only subject to the following conditions: locally applied exhaust ventilation, so as to remove dust and fumes at the point of origin; cleanliness of tools and workrooms; notification to Government authorities of all cases of lead poisoning and compensation therefore; periodic medical examination of the persons employed in such processes; provision of sufficient and suitable cloakroom, washing, and mess-room accommodation, and special protective clothing; prohibition of bringing food or drink into workrooms.

The Conference also recommends that in those industries where it is possible to substitute non-toxic substances for the soluble salts of lead, the use of the said soluble salts of lead should be vigorously controlled. All salts of lead containing more than 5 per cent. of their own weight in metallic lead in a 0.25 per cent. solution of hydrochloric acid are to be considered as soluble.

Legislation as to the age of young persons on admission varies from one country to another. Thus, for example, in Italy and in Japan lads under 15 years of age are excluded from white lead works, under 16 in Argentina, Belgium, Germany, Greece, Spain; under 18 in the British Empire and the Netherlands.

Young persons under 15 years of age are excluded from lead colour factories in the State of Delaware; under 16 in the States of Alabama, Arizona, California, Colorado, Connecticut, Florida, Illinois, Kentucky, Maryland, Missouri, Nevada, New Jersey, New York, North Dakota, Ohio, Oklahoma, Utah, Vermont, Wisconsin, Wyoming, in Germany and Belgium, Greece, and Argentina; under 18 in Great Britain, South Africa, Western Australia, New South Wales, Victoria, Tasmania, Norway, Poland; under 21 in Pennsylvania. Women under 18 are excluded from white lead factories in South Africa, in Greece and in the province of Quebec and under 21 in Italy (see article "Lead").

Special Legislation on White Lead Factories and Use of White Lead
(See also article "Painting Industry").

**Wine and Spirit Industry**


Wine is the product of the fermentation of grape-must, which, in its turn, is derived from crushed grapes. Must consists of a collection of substances dissolved in water squeezed straight from the grape. Water, then, is its principal constituent.
The composition of the must, and consequently of the wine which comes from it, varies in different countries according to the quality of the grapes and the process of its production. It will suffice here to speak of the kinds used in making ordinary table wines, in order to convey an exact idea of any strain arising from work connected with wines and musts.

During the fermentation of musts, which is carried out in large vessels, usually in vats, the sugar, or glucose, present in the must, is decomposed, and converted into alcohols which dissolve in the fermenting liquid, and also into carbonic anhydride, which for the most part escapes into the surrounding air.

If large amounts are liberated in closed, confined or badly ventilated premises, the personnel working at the vats is exposed to serious risk from poisoning, which may manifest itself as a slight indisposition with general discomfort, headaches, dizziness or a singing in the ears, or by more serious symptoms, such as fainting or even sudden death from suffocation.

The work entrusted to the cellarmen, following the maturing of the wine in the vats, commences with emptying the vats and putting the wine into barrels. In the meantime, while the first wine is in the cellars, it has to undergo another fermentation — the second, or slow, fermentation — still under the action of *Vini mycoderma*; this results in the formation of alcohol and carbon dioxide. The marc or residuum is then pressed in order to prepare the second wines.

Wines in barrels require special attention during the eventual alcoholic poisonisation arising from rackings off, clarifying and filtration. Finally, the wine passes from the barrels into such smaller receptacles as casks and bottles, ready for being placed on sale and for consumption.

This series of operations offers many opportunities for exposure of the personnel of the wine-cellars to industrial alcoholic poisoning. Although acute intoxication by ethyl alcohol in the case of drinkers is well recognised as a cause of accidental or habitual drunkenness, and although chronic indulgence in alcoholism is well known as a cause of disease; on the other hand, much less attention is devoted to the problem of acute or chronic occupational poisoning.

**Statistics**

Data relative to the hygienic and sanitary conditions of workers in this occupational category are not numerous (for mortality statistics, see article "Alcohol, Intoxication by ").

An article by Granjux on the state of health among workers in a factory where Bordeaux liqueurs were made was published in 1908. This expert was struck by the absence of cases of alcoholism among the workmen of the said factory, by the number of elderly people among the employees and by the small proportion of lost time. There was no weekly round of tasks as adopted by the Chartruese monks, but, instead, machinery had been so developed there as to allow the alcohol to be manipulated in closed vessels, and to prevent its evaporation in the workshops.

About a third of the staff were more than fifty years old, which is explained by a very humane idea adopted by the management: old workmen who are tired out, but not diseased, are put on work which gets increasingly easier. They too, when pensioned off, in proportion to those at work in the factory, was 6 per cent.; morbidity among the workers was also negligible, the percentage of days of absence having been only 2.18, a very low rate if there be taken into consideration the fact that two-thirds of the workers were women, and that the old workmen were kept on as long as they were capable of rendering any service whatsoever.

This state of things is accounted for by the use of machines, by selection of the factory hands and by the adoption of such measures for general health as spacious, well- aired and clean workshops, automatic or mechanical labour, and dining halls.

There should also be mentioned the steps taken by the management to assure the good health of its employees by setting up canteens in the workshops to protect the workmen against the attraction of the wine-merchant; by instituting a system by which the workman is provided with free drinks in exchange for coupons, of which they received a fixed number every week; by establishing houses in the country; by medical assistance with free choice of doctor; and by medical assistance during maternity and for working mothers.

Delaunay in 1924 also examined a certain number of Bordeaux cellarmen, without, however, finding among them any illness peculiar to their work. He holds that the principal influences conducive to unhealthiness are lack of air and light with humid conditions; but he considers that wine fumes and sulphurous emanations have practically no effect on the constitutions of cellarmen. Rheumatism, on the other hand, is frequent, but tuberculosis is exceptional.

This expert, as likewise Léon Meunier in 1928, has, on the other hand, referred to forms of illness peculiar to "wine-tasters", who have every day to taste 100, 150, 200 or even more samples. Tasting consists, first of all, in inhaling the aroma of the liquid under examination, whether wine, liqueur or alcohol, next in taking a mouth-
ful into the buccal cavity, where it is rolled round in contact with the taste bulbs, and then in spitting it out, so that the same process may be repeated on another sample. These tasters complain of marked fatigue, of a feeling of irritation in the throat and of stomach troubles, which affect novices the most, as after a time the worker grows accustomed to the process. These affections of the glanulard and motor activity of the stomach are of necessity reflex phenomena, because the taster never swallows the liquid.

Badham in 1924 studied the health conditions in certain wine-cellarSydney; he examined 63 workmen, among whom he found an undue incidence of lesions of the renal arteries. A case of pulmonary tuberculosis was attributed by Badham to insufficient ventilation in the wine-cellar where the man worked. Two cases of lead poisoning were caused by the use of a mixture of white lead and turpentine for the painting of the barrels. Analysis of the air established that the amount of carbonic acid present varied between 3.8 and 11.9 parts per 10,000 of air. But it is well known that workmen who are accustomed to live in such an atmosphere do not realise the unhealthy state of the atmosphere. Alcohol and ether vapours are given off whenever the liquid is being poured, whilst wine is being racked, from any winy mass collected in vessels, from wine which is often spilled on the ground, and from that which falls on the outside of bottles and casks. The evaporation of alcohol is also facilitated by the coming and going of the workers, and by the high temperature of the cellar.

PATHOLOGY

Alcohol can be absorbed even through the unbroken skin. But it is well known that the absorption of alcoholic vapours by the respiratory tracts after inhalation is both easy and rapid. Men who fill barrels and bottles with ordinary table wines standardised at from 10° to 14°, or choice wines which have a higher degree of alcohol, show acute symptoms of ordinary intoxication, which may be serious or even induce coma. There are on record several clinical observations of serious and acute intoxications from ethyl alcohol among wine-bottlers, working in close places, without these individuals having actually drunk a single drop of wine (Pieraccini). Intoxication due to swallowing, which would at least act as a help to inhaled alcohol, was ruled out on vomiting being induced artificially. The matter vomited did not contain traces of alcohol, although it was present in the urine.

Intoxication and drunkenness are found among cellarmen occupied in racking wines, and, most of all, among the bottlers. In short, alcoholic fumes are given off from the surface of the wine, and from the opening of the tap to the bottle; they form, especially if the stream is divided into secondary jets, a fine mist, on account of the wine striking against the neck of the bottle or the inner sur-

face of the funnel. The clash of wine and air causes the formation of a certain quantity of tiny droplets, which carry alcoholic fumes. In the same way, little bubbles of air escape from the mass of liquid, when it is being disturbed at the moment of racking, and particularly when sparkling wines are being racked. Yet this danger is less serious when bottling is carried out by mechanical or automatic devices.

Other substances, such as volatile ethers, which are present in wine may also cause occupational drunkenness.

Akin to acute intoxication, a form of chronic intoxication, of occupational origin, occurs amongst wine-makers. In the closed places where the preparation, storing and manipulation of wines take place, the atmosphere is continually full of alcoholic vapours and wine fusel oils. The smell soon warns strangers who come into these places by chance of the state of affairs. But it is well known that workmen who are accustomed to live in such an atmosphere do not realise the unhealthy state of the atmosphere. Alcohol and ether vapours are given off whenever the liquid is being poured, whilst wine is being racked, from any winy mass collected in vessels, from wine which is often spilled on the ground, and from that which falls on the outside of bottles and casks. The evaporation of alcohol is also facilitated by the coming and going of the workers, and by the high temperature of the cellar. Chronic occupational alcoholism may assume all the pathological forms characteristic of chronic indulgence in alcohol. Theoretically a difference should be recognised between the two forms of poisoning, on the supposition that inhaled alcohol acts principally on the nerve centres, which are more sensitive to the poison, although the alcohol reaches the different organs uniformly through the circulation; on the other hand, ingested alcohol not only causes lesions, through direct action on the pharynx, the oesophagus and the intestines, but is even able to attack the liver more seriously and more directly.

The chronic occupational form is dangerous also because it comes on in an insidious manner, and because it is generally combined with the form due to indulgence; hence the ingested and inhaled alcohol combine their injurious action. Nevertheless, an equal quantity being taken of each and absorbed for the same length of time, inhaled alcohol seems to act more vigorously than ingested alcohol, because the latter, if it is taken at ordinary
meal times, settles down to a certain extent with food, whereas inhaled alco-
hol gains access unaltered and rapidly, and can strike immediately — that is,
without first undergoing any chemical changes — at those vital organs which
are most richly supplied with blood, of which, of course, the brain stands
first.

This occupational alcoholism, description of which dates from Ramazzini1,
occurs, not only among cellarmen, but also among wine-tasters, agents and
wholesale merchants, and innkeepers who sell wine in small quantities by
the glass. Among these persons wine fumes, inhaled occupationally, may be
the forerunner of eventual alcoholism through ingestion.

The tannin present in the must and
the wine may also be a source of
trouble to the workers. Tannin, even
in a very dilute solution, exercises a
cogulating action on animal tissues,
more especially so if the contact is pro-
longed. Hence, the hands and fore-
arms of cellarmen, who almost always
have their hands steeped in the wine,
are subjected to prolonged soaking
in alcohol and tannic substances dis-
solved in the musts, the lees, the marcs
and the wines. In this case the de-
hydrating action of the alcohol coagul-
ates and precipitates the albumens,
and that of the tannin also coagulates
the albumens and collagenous sub-
stances. Under their combined action
the skin becomes blackish, dry, hard,
cracked and sometimes covered with
deep and painful sores. The water
from the musts and wines, penetrat-
ing the tissues of the hands, reinforces
the caustic action of the tannic mat-
erials by maceration.

Other processes in the manipulation
of wines are worthy of note, such as
sulphuring the receptacles, both vats
and barrels, and certain treatment for
correcting any irregularities or faults
in the wines by the use of sulphuric or
sulphydric acid.

Under the heading of “distillation
and manufacture of spirits” may be
grouped the distillation and refining of
alcohol (for details, see article “Alco-
hol”); the manufacture of brandy,
obtained through distilling wine or the
lees of the vintage; the preparation of
special liqueur-brandy, with the help of
trade-alcohol and of substances to
improve the quality; and, lastly,
the manufacture and distillation of
liqueurs, such as aperitives and ordi-
mary or choice liqueurs.

The inhalation of carbon dioxide
of wine fumes given off from musts
and from vinasses and wines, and of
alcoholic vapours in distilleries and
liqueur factories, represents the most
important occupational risk. This risk
can be mitigated or overcome by pro-
viding spacious, clean, well-ventilated
workplaces, and using mechanical de-
vices for crushing the grapes in the
vats, for pressing the vinasses and for
racking the wines. The processes of
distillation, of rectification and the
manipulation of alcohols and liqueurs,
can be carried out in closed vessels,
by ensuring the transit of the liquids
from one receptacle to another by means
of compressed air or by pumps.

Rjasanow in 1931 studied the per-
centage of carbon dioxide present in the
fermentation rooms of distilleries and
alcohol factories. The daily cleansing
and disinfection of the fermenting vats
sometimes necessitates the workmen
entering the vats or bins — a danger-
ous practice, too often fraught with
fatal results.

The amount of carbon dioxide depends
on the stage of fermentation. Rjasa-
now found quantities ranging from a
minimum of 2.4 per cent. to a maxi-
imum of 16 per cent. These amounts
vary according to the ventilation of
the premises; ventilation is also essen-
tial, within certain limits, for a good
production.

The cleaning out of the vats and bins
ought to be done under a jet of cold
water, which much reduces the amount
of carbon dioxide owing to its solubility
in cold water; hot water, on the other
hand, increases the amount.

**Hygiene**

Every step possible should be taken
to avoid the risk of scalding, through
splashes from jets of hot alcohol or
fluids.

In accordance with the precepts of
occupational hygiene and social wel-
fare, all young persons, children and
women should be prohibited from work
at storing and manipulating wine in
cellars and distilleries, and also all per-
sons predisposed to neurotic symptoms,
as, for example, neuropathics and
epileptics, because these occupations
offer opportunities for drink and for
acquiring harmful habits. It is true
that alcohol inhaled and circulating
in the human body becomes, at any rate
in small quantities, oxidised and
utilised as a source of heat and energy;
but, in this case, the amount of alco-
hol drunk should remain always very
small, and the inhalation of wine fumes

1 "Ex odore et vini spiritibus per aorem dis-
persis, ac per os et nares. . ." (Chap. XXI).
should form an exceptional occurrence, and not a daily occupational rule.

Be that as it may, the selective action of alcohol on the nervous system is, even in very small quantities, to be feared for young people, whose nervous system is in course of development, and consequently ultra-sensitive to all poisons.

As regards its effect on the female organism, it will suffice to say that alcohol exerts a maleficient influence on the ovum, just as it does on the spermatozoon, on the embryo and the foetus, and that it is excreted through lactic secretion, which is a danger for the organism, on the ovum, just as alcohol on the nervous system is, and not a daily occupational rule.

Adequate measures must be taken to ensure good ventilation and sufficient lighting of underground places; cement floors with narrow grooves and so sloped as to ensure the drainage of fluids are to be recommended. Mechanical methods should be adopted for barrelling and bottling. Measures for individual cleanliness must also be provided.

**Legislation**

In Belgium young persons under fourteen years are not allowed to work at distilleries, in malt-houses and places where the fermentation is carried out, nor at distilleries for liqueur spirits, in the places where the actual distilling is done. Special laws have been passed in Germany: in Prussia (1901) relating to work in the fermentation departments of distilleries, and in Bavaria (1903) relating to the arrangement of wine-cellars during the fermentation of the wine.

Compensation for chronic occupational intoxication among the workers in distilleries is accorded in Chile.

**Coopers**

The health conditions of coopers are similar to those of makers of vats, tubs, kegs and casks, so that all these men may be grouped under the general heading of "makers of receptacles for wine", and what follows relating to the occupational health of coopers applies also to that of these other workers.

A cask is a wooden vessel which is used for the collection and transport of liquids, and especially of wine. It consists essentially of staves, that is to say, of tapering strips of wood, which constitute the body of the cask, whether cylindrical or oval in shape, and of two circular ends, which close the cask, one at the top and the other at the bottom. Planks of wood are used which are straight or slightly convex towards the interior, so that they can best withstand the pressure of the liquid.

A cask is provided with an opening or bung, that is to say, a round hole made in the upper part of the body of the cask in its widest part. It is through this hole that the liquids are emptied out. A cask is also provided with a small opening, low down near the end in front, which is used for cleaning the inside or for fixing the tap ready for drawing the contents.

For the construction of casks, wood of hard and close fibre is used, which does not allow liquid to leak through, and preserves it well, whilst the wood, in contact with the fluid, becomes harder, more compact and more resistant.

Large squared planks of wood pass from the hands of the woodcutter to the hands of the cooper, who, with saw and axe, rough-hews them and makes them equal in size. Rough hand-work with the axe produces a tremendous quantity of wood-chips, but not dust; whereas work with the mechanical or hand saw makes dust, but nevertheless not very much of it, the wood worked not being too dry. These operations are tiring, but are not bad for the health of the worker.

On the other hand, the ordinary planning and work with the moulding-plane, as well as hollowing the grooves necessary to take the two ends of the cask, produce small chips and much dust, especially when the wood is dry.

Generally speaking, in modern factories, these processes are carried out by machinery, but in small workshops hand-tools are used. In both cases dust is abundant, a dust which is fine, hard, stinging and full of tannins.

It must be added that the machines spray out the dust to some distance, and throw off little chips so violently that the workmen have to protect themselves with respirators and goggles. With hand-work the raising of dust is less important, but the workman raises it from time to time with his hand or with a brush, or even blows it up with his mouth, from the piece on which he is working.

The workers complain of coughs, and of a parched feeling in the nasal and pharyngeal mucous membranes. The inhalation of dust may set up tracheo-bronchial catarrh.

The pressing out and curving of staves is done by putting the dry staves, already prepared, into special boxes, which soften them and make them pliable and unlikely to break. Accord-
ing to an old custom, still quite extensively followed, the staves are softened by being left in hot water for about twenty-four hours. In up-to-date factories, the staves are put into large metal vessels, into which steam from boiling water is passed. The water in these baths changes into a blackish liquid, rich in tannic matter.

As a rule, the workmen occupied in pressing and curving suffer no injury, but if they put their hands and forearms into the liquid, or handle the damp staves, the local and direct action of the tannin on the skin, where the humidity, by macerating the skin, helps the action of the tannin, desiccates and hardens the skin, and sometimes causes cracks which may be comparatively deep and painful. The actual curving of the staves is done by machines.

As soon as the cask is mounted, held together by a temporary hooping of wood and adjusted, the outside surface is planed and smoothed. This procedure also generates dust. Lastly, the cask passes on to its real hooping, with iron rings, to which are also added wooden hoops, to protect it against joltings when being rolled on hard surfaces.

Sometimes the outside of the ends are varnished, and liquid paraffin is poured into the cask in order to coat the inside wall with a thin layer, and so make it less permeable to liquids. The paraffin is melted by heat in a cauldron. Irritation of the conjunctiva has been reported, and of the respiratory passages, with coughing. In serious, but very rare, cases, fits of suffocation occur, and also bronchitis and dermatitis due to direct irritation of the skin.

**Hygiene**

The workers should be protected against accidents due to flying chips by goggles, and against the sawdust by respirators. When the work is done by machinery, protection is easily effected by fitting the machines with suitable safeguards, and localised exhaust ducts. Measures for protection must also be taken during the preparation and use of paraffin.

**Prof. G. Pieraccini**
(Florence).

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Women's Work


The industrial employment of women, largely brought about by the industrial revolution which commenced in Great Britain at the beginning of the nineteenth century, finds its explanation in the following reasons: application of mechanical power to operations until then confined to men; increase in the demand for semi-skilled or unskilled labour; industrialisation of certain products until then prepared by women in their homes (spinning, lace-making, knitting, sewing, fruit-preserving, etc.).

The lack of male labour brought about by the war naturally increased the number of women employed in industry. This fact soon drew the attention of Governments to the evil consequences of factory work both for the woman and for the race. To-day economic and political reasons certainly compel women more and more to abandon domestic and family life for industrial, commercial and intellectual occupations — factors which determine the pathology and hygiene of women's work, giving to the first its seriousness and to the second its importance.

Available statistics show that the number of women engaged in industrial work are as stated in the table on the next page.

In Japan the number of active women between fifteen and sixty years of age is, according to Teruoka, 16,731,000, of whom about 60 per cent. have some occupation (agriculture, 6 per cent.; industrial employment, 14 per cent.; commerce, 9 per cent.; domestic service, 6 per cent.; public institutions, 3 per cent.; factories, 9 per cent.; transport, 6 per cent.). In 1892, 856,182 were employed in industry, 71,349 in mines, 331,372 in other occupations (13 per cent. of the female population). In 1923, 74 per cent. (about 856,000) of the women workers were in factories, of which 736,153 were in the textile industry and dyeworks, 14,394 in engineering workshops, 51,549 in the chemical industries, and 21,955 in different industries.¹

¹In Japan the largest number of women work, as has been said, in the textile industry and dyeworks (86 per cent. of all working women) where 86 per cent. are of the female sex. According to the 1923 statistics, among the 856,000, women workers in factories, 966,000 were female young persons under sixteen years of age, of whom 900,000 were employed in textile mills and dyeworks. It is important to remember, too, that 80 per cent. of the women worked ten to twelve hours a day, and that, in 1922, 30 per cent. of the factories working night
The injurious effects of labour on the female organism are established by quite a series of statistical data. At the same time, according to some authorities (Collis), as the verification of these statistics is difficult it would be well to accept them with a certain amount of reserve. Women indeed are not generally subjected to industrial influences for more than ten years, but it is also true that, in contradistinction to what is the case with men, many more women are exposed during this relatively short period to the detrimental effects of industry. So much so is this the case that the definite effect of industrial labour on the female population is much greater than that represented at any given moment by the number of women employed in factories. An effort would, therefore, require to be made to seek to find out the remote consequences of employment on women who have left work — a thing which is practically impossible. On the other hand, industrial work constantly increases or aggravates the number of maladies from which young women suffer: chlorosis, anaemia, disorders of the nervous system, of the organs, etc.; disorders which, more than in the case with men, stand in close relation with external factors (wages, housing, food, clothing, etc.). This is the reason why the unskilled worker, to which class women belong, reveals statistically infinitely worse health conditions. Climate, social environment, and technical organisation determine, in different countries, and even in the same country, the differing sanitary conditions to which women workers are subjected in the same industry. Thus, for example, in Japan, while formerly the example, in Japan, while formerly the

### Table: Number of Women Employed in the Different Countries and the Relative Proportion Thereof to the Total Number of Employed in the Population, and to the Total Female Population According to the Results of the Last Census (in Thousands)

<table>
<thead>
<tr>
<th>Country</th>
<th>Census year</th>
<th>Total employed persons</th>
<th>Total women employed</th>
<th>Total female population</th>
<th>Total of women employed in relation to total employed population</th>
<th>Percentage of employed women in relation to the total female population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>1914</td>
<td>3,169.4</td>
<td>684.3</td>
<td>2,658</td>
<td>21.6</td>
<td>18.7</td>
</tr>
<tr>
<td>Australia</td>
<td>1921</td>
<td>2,930.8</td>
<td>492.0</td>
<td>4,473</td>
<td>19.7</td>
<td>17.1</td>
</tr>
<tr>
<td>Austria</td>
<td>1920</td>
<td>3,084.0</td>
<td>1,115.0</td>
<td>3,195</td>
<td>36.1</td>
<td>34.8</td>
</tr>
<tr>
<td>Belgium</td>
<td>1920</td>
<td>3,203.2</td>
<td>932.5</td>
<td>1,731</td>
<td>25.0</td>
<td>23.3</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>1920</td>
<td>3,060.3</td>
<td>1,174.8</td>
<td>2,436</td>
<td>45.1</td>
<td>48.4</td>
</tr>
<tr>
<td>Canada</td>
<td>1921</td>
<td>3,172.2</td>
<td>490.2</td>
<td>4,588</td>
<td>15.4</td>
<td>11.3</td>
</tr>
<tr>
<td>Chile</td>
<td>1920</td>
<td>1,948.4</td>
<td>256.0</td>
<td>1,888</td>
<td>26.0</td>
<td>18.3</td>
</tr>
<tr>
<td>Cuba</td>
<td>1919</td>
<td>949.9</td>
<td>89.7</td>
<td>1,358</td>
<td>9.4</td>
<td>6.6</td>
</tr>
<tr>
<td>Czechoslovakia</td>
<td>1921</td>
<td>6,515.9</td>
<td>1,669.7</td>
<td>7,054</td>
<td>30.2</td>
<td>27.9</td>
</tr>
<tr>
<td>Denmark</td>
<td>1921</td>
<td>1,261.6</td>
<td>404.0</td>
<td>1,675</td>
<td>32.6</td>
<td>34.1</td>
</tr>
<tr>
<td>Egypt</td>
<td>1917</td>
<td>5,846.5</td>
<td>1,270.3</td>
<td>6,434</td>
<td>33.8</td>
<td>31.1</td>
</tr>
<tr>
<td>Estonia</td>
<td>1922</td>
<td>624.9</td>
<td>219.5</td>
<td>843.4</td>
<td>40.0</td>
<td>45.8</td>
</tr>
<tr>
<td>Finland</td>
<td>1920</td>
<td>1,483.7</td>
<td>611.3</td>
<td>1,706</td>
<td>40.7</td>
<td>36.5</td>
</tr>
<tr>
<td>France</td>
<td>1921</td>
<td>21,726.0</td>
<td>8,006.1</td>
<td>20,333</td>
<td>39.6</td>
<td>42.9</td>
</tr>
<tr>
<td>Germany</td>
<td>1925</td>
<td>32,008.8</td>
<td>11,477.7</td>
<td>33,486</td>
<td>33.8</td>
<td>36.6</td>
</tr>
<tr>
<td>Great Britain:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>England and Wales</td>
<td>1921</td>
<td>17,129.6</td>
<td>5,056.0</td>
<td>19,860</td>
<td>29.4</td>
<td>25.5</td>
</tr>
<tr>
<td>Scotland</td>
<td>1921</td>
<td>5,195.3</td>
<td>836.1</td>
<td>5,031</td>
<td>26.5</td>
<td>25.0</td>
</tr>
<tr>
<td>Hungary</td>
<td>1920</td>
<td>3,638.8</td>
<td>1,073.9</td>
<td>4,112</td>
<td>50.3</td>
<td>52.1</td>
</tr>
<tr>
<td>India</td>
<td>1921</td>
<td>140,648.0</td>
<td>44,027.1</td>
<td>4,138,689</td>
<td>31.3</td>
<td>48.7</td>
</tr>
<tr>
<td>Ireland</td>
<td>1921</td>
<td>1,460.5</td>
<td>497.9</td>
<td>1,958</td>
<td>31.6</td>
<td>27.8</td>
</tr>
<tr>
<td>Italy</td>
<td>1921</td>
<td>18,431.1</td>
<td>5,276.6</td>
<td>19,891</td>
<td>20.6</td>
<td>20.3</td>
</tr>
<tr>
<td>Latvia</td>
<td>1921</td>
<td>941.3</td>
<td>457.4</td>
<td>985.8</td>
<td>49.7</td>
<td>46.4</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>1921</td>
<td>119.6</td>
<td>35.3</td>
<td>154.8</td>
<td>21.8</td>
<td>27.3</td>
</tr>
<tr>
<td>Mexico</td>
<td>1921</td>
<td>5,683.0</td>
<td>271.9</td>
<td>5,954.9</td>
<td>13.0</td>
<td>9.9</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1921</td>
<td>511.6</td>
<td>113.5</td>
<td>625.1</td>
<td>21.6</td>
<td>18.5</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1920</td>
<td>2,732.4</td>
<td>331.8</td>
<td>3,064</td>
<td>32.2</td>
<td>25.2</td>
</tr>
<tr>
<td>Norway</td>
<td>1920</td>
<td>1,070.4</td>
<td>258.0</td>
<td>1,328</td>
<td>27.8</td>
<td>21.9</td>
</tr>
<tr>
<td>Portugal</td>
<td>1921</td>
<td>9,540.0</td>
<td>606.9</td>
<td>10,146</td>
<td>27.3</td>
<td>22.2</td>
</tr>
<tr>
<td>Rumania</td>
<td>1921</td>
<td>3,780.6</td>
<td>1,748.5</td>
<td>5,529</td>
<td>25.6</td>
<td>47.2</td>
</tr>
<tr>
<td>South Africa</td>
<td>1921</td>
<td>3,799.0</td>
<td>1,657.2</td>
<td>5,446</td>
<td>43.6</td>
<td>46.8</td>
</tr>
<tr>
<td>Spain</td>
<td>1921</td>
<td>7,498.1</td>
<td>1,013.9</td>
<td>8,512</td>
<td>13.5</td>
<td>14.8</td>
</tr>
<tr>
<td>Sweden</td>
<td>1920</td>
<td>2,077.0</td>
<td>366.8</td>
<td>2,443</td>
<td>25.3</td>
<td>25.5</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1920</td>
<td>1,871.7</td>
<td>456.4</td>
<td>2,328</td>
<td>33.9</td>
<td>31.6</td>
</tr>
<tr>
<td>United States</td>
<td>1920</td>
<td>41,814.2</td>
<td>8,549.5</td>
<td>50,150</td>
<td>20.5</td>
<td>16.5</td>
</tr>
</tbody>
</table>
women workers were unmarried or young women, to-day there are a great many who are married, because the number of women who take to industrial work without the spur of necessity, to obtain money for marrying or for other economic reasons, tends to increase more and more.

The systematic recruitment of female labour from the rural districts is pushed very much in Japan, and it is so expensive that, by way of compensation for the loss incurred, wages have had to be lowered and hours of work increased. It is not necessary to enter into greater detail as the information can be found in the works of Teruoka (1926). It will suffice to say that the majority of the women employed in these factories (89 per cent. at least) live in hostels belonging to the factory, which ensures them lodging and food. The importance of this for the young working woman is evident. Although the nourishment furnished by the factory yields about 2,000 calories and contains about 50 grm. of protein daily (for a girl of 40 kg. weight, 50 calories is about equal to 1 grm. of protein per kg.), the researches of Shimazono go to prove that this quantity is not enough for a growing girl. He considers that the food again is insufficient in protein and in vitamin B. The food, as well as the environment, explains the high incidence of absence from work and sickness. It is not however possible to draw conclusions about a particular class of industrial worker, because, to cite one example, the tobacco industry in a country in which it is a monopoly (Italy, France) shows a minimal morbidity, while in other countries where the work is mainly done in the home, the situation from a health aspect is much more serious.

### Statistics

The injurious effect of employment is proved by the sickness statistics of sickness Insurance Societies, etc. According to those published by the German Labour Ministry, the sickness rate of women, when compared with that of men, shows an increase in the number of cases for the age groups from twenty to fifty-five years of age, as well as an increase in the number of days of sickness for the group of sixteen to fifty-five years.

In the German textile industry (Deutscher Textil Arbeiterverlag, 1925), the morbidity rate was 48.1 for women and 28.7 for men. The Leipzig Society makes the following comparison:

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Number of cases of sickness per annum and per 100 members of the Society</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
</tr>
<tr>
<td>15-24 years</td>
<td>36.4</td>
</tr>
<tr>
<td>25-34 years</td>
<td>36.8</td>
</tr>
<tr>
<td>35-44 years</td>
<td>42.9</td>
</tr>
<tr>
<td>45-54 years</td>
<td>48.7</td>
</tr>
<tr>
<td>55-64 years</td>
<td>56.1</td>
</tr>
<tr>
<td>65-74 years</td>
<td>70.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Number of cases of sickness amongst women in proportion to 100 cases amongst men</th>
<th>Number of cases of gynaecological diseases per 100 women during one year</th>
<th>Morbidity of the women in proportion to that of the men (=100) after eliminating accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>104</td>
<td>199</td>
<td>106</td>
</tr>
</tbody>
</table>

According to Hirsch (1927), of 3,165 pregnancies occurring in the textile industry during the period 1924-1926, 34 per cent. of the confinement cases ought to be regarded as pathological; in 30.3 per cent. assistance from a doctor was called for; 46.8 per cent. of the pathological cases and 39.2 per cent. of the lying-in cases which necessitated the intervention of the doctor occurred to women working in a standing position; the percentages are lower for those working seated; 30.7 for the pathological lying-in cases and 24.1 for those requiring medical intervention. In the State of Baden, the figures for the average population (1920-1925) are sensibly lower than in the textile industry.

In 13.2 per cent. of the cases there was partial incapacity for work during the pregnancy of which 16.6 per cent. were standing at their work and 12.1 per cent. sitting; 24.2 per cent. of the women were totally incapacitated and of these 25.3 per cent. worked standing and 22.2 per cent. sitting. Total incapacity commenced in a few cases at the third month, but in the great majority of the cases in the course of the seventh. It was observed that the women who worked either seated or standing complained to the same degree of dorsal and renal pains. On the other hand, abdominal pain was more frequent in the latter and varicose veins three times as numerous as in the case of the women working seated.

The conclusion may be reached that the professional class who work standing (86 per cent.) are the more exposed to injury of the genital organs.

An official enquiry in the State of New York in 1919 showed that women present a higher morbidity and a longer duration of sickness than men:
The statistics show, therefore, that the average incapacity for work and average duration of sickness are higher among women than men. But two other important considerations arise: one is that among working women more than one-half of them are under thirty years of age and nearly three-quarters under forty years; the other is that 93 per cent. of the children (German statistics) are brought into the world by women of from twenty to forty years of age (twenty to thirty years, 60 per cent.; thirty to forty years, 33 per cent.). The conclusion, therefore, is evident that the combined action of the occupational influences and of pregnancy do constitute a considerable danger for women.

Statistics drawn up by the Carders' Union of Great Britain give the following value for the causes of absence:

<table>
<thead>
<tr>
<th>Causes of Illness</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidents</td>
<td>3,003</td>
<td>4,046</td>
</tr>
<tr>
<td>Anaemia</td>
<td>290</td>
<td>304</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>286</td>
<td>329</td>
</tr>
<tr>
<td>Diseases of the heart and blood vessels</td>
<td>301</td>
<td>409</td>
</tr>
<tr>
<td>Influenza and colds</td>
<td>100</td>
<td>137</td>
</tr>
<tr>
<td>Neurasthenia, neuragias</td>
<td>92</td>
<td>142</td>
</tr>
<tr>
<td>Rheumatism</td>
<td>277</td>
<td>339</td>
</tr>
<tr>
<td>Sexual diseases</td>
<td>304</td>
<td>415</td>
</tr>
<tr>
<td>Digestive diseases</td>
<td>433</td>
<td>418</td>
</tr>
</tbody>
</table>

According to Bernays, the rhythm of machinery is not adapted to the female organism, which requires an effort to follow it and in consequence becomes exhausted. This fatigue, more noticeable in pregnant women, makes them less attentive (whence the greater frequency of accidents among them) and more susceptible to intoxications. In English munition factories, Osborne found that women employed on light work for sixty-one hours a week had an incidence of accidents 91 per cent. higher than that of men doing the same work. When hours were forty per week the incidence fell only to 78 per cent. more than that of the men.

Campbell found that among 2,800 women employed in munition factories, 42 per cent. were away on account of overwork or illness. In the Austrian State tobacco factories, 47.1 per cent. of the women were ill at a given moment as compared with 28.7 per cent. of the men. In Switzerland Schaller found a morbidity rate of 129 for women as compared with 100 for men. Prior to the war, the excess of sickness among women in Germany and Austria was calculated at about 10 per cent.; but after the war it certainly increased, even with a shortened working day.

According to Phillips, the hours for women are still too long — at any rate in certain countries: sixty hours, for example, per week, in Bulgaria, and in India; seventy in Japan (1922), etc.

Finally, intellectual work is said to be a still heavier cause of sickness among women. Statistics from Stettin, Kiel, Mannheim, Munich, and Hamburg (1902-1909) as to school mistresses gave an incidence of 6.4 to 10.3 for them as against 2.8 to 5.0 for men, and a duration of sickness of 14.8 days on an average as against 6.7 for men. The same holds good for those engaged in office work. Frcdet (1924), after observing for six consecutive years 667 women employed in an administrative service on the French railways, found that they were ill three times as often as men in the same department and that the sick leave in the case of the women was 4.4 times as great as that of the men. Neither pregnancy, nor confinement and their sequelae were counted. A Swedish Commission (1924) was able to establish the fact that the proportion of illnesses among the women officials was 14 per cent. higher than that among the men. Several enquiries during the war tended, however, to show that occupational work is not such an important factor in morbidity and occupational mortality as some authorities think.

Where, however, the morbidity rate is higher among women than among working women, the reason is that the duration of work in the case of the latter is, especially in some countries, insufficient to cause serious occupational disease.

Detailed study of the causes of sickness immediately brings out the fact that it is the function of maternity which is most affected, because general illnesses, such as those of development, etc., are more
frequent among men, although it may not be always possible to establish, for certain of them, a direct relation with the occupation.

On the other hand, in the case of anaemia among women it is easy to show its relation to work. As a matter of fact, for the age group 15-19 years, anaemia is fifteen times more frequent than among males and for the group above 49 years, seven times. In 75 per cent. of the cases observed it is believed to be the cause of chlorosis, anaemia and neurasthenia (Roth). The same conclusions hold good for general causes, such as exhaustion, loss of energy and malnutrition. The highest incidence of cases of these illnesses is accompanied by the greatest duration of incapacity.

The statistics of mortality show generally that the average death-rate of working women is higher than the general average and than that of men up to the age of thirty to forty years, that is, at the age at which female labour is especially recruited. As compared with 100 men who die, the mortality of women in the different age groups is as follows:

<table>
<thead>
<tr>
<th>Ages</th>
<th>Figures of the Leipzig Sickness Insurance Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-20 years</td>
<td>99</td>
</tr>
<tr>
<td>20-25</td>
<td>104</td>
</tr>
<tr>
<td>25-30</td>
<td>103</td>
</tr>
<tr>
<td>30-35</td>
<td>90</td>
</tr>
<tr>
<td>35-40</td>
<td>76</td>
</tr>
<tr>
<td>40-45</td>
<td>68</td>
</tr>
<tr>
<td>45-50</td>
<td>71</td>
</tr>
<tr>
<td>50-55</td>
<td>74</td>
</tr>
<tr>
<td>55-60</td>
<td>74</td>
</tr>
</tbody>
</table>

The mortality per thousand persons living in Austria is said to be as follows according to Prinzling:

<table>
<thead>
<tr>
<th>Ages</th>
<th>All male workers</th>
<th>All female workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-20 years</td>
<td>5.2</td>
<td>8.1</td>
</tr>
<tr>
<td>20-25</td>
<td>6.6</td>
<td>9.2</td>
</tr>
<tr>
<td>25-30</td>
<td>9.0</td>
<td>10.0</td>
</tr>
<tr>
<td>30-35</td>
<td>14.2</td>
<td>12.4</td>
</tr>
<tr>
<td>35-40</td>
<td>17.1</td>
<td>17.1</td>
</tr>
<tr>
<td>40-45</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

With reservations to any criticism which may be passed on the way these statistics are drawn up, several of them tend to show that anaemia is greater (in age groups 20-35 and 45-50) among working women than among those who have not to work (Leipzig Sickness Insurance Society).

The excess of mortality between twenty and thirty-five years of age can be explained by the influence of the sexual life, which is at its height at this period. On the other hand, in the case of women between forty-five and fifty years of age, the high mortality may be attributed with probability to the suppression of the function of maternity. The same reason can partly explain why mortality at the same age groups is higher in women than in men.

GENERAL PHYSIOPATHOLOGY

The influence of employment on the female organism depends on two sets of factors: (a) those which depend on the female constitution, and (b) those due to the work itself.

(a) Sex is one of the coefficients of aptitude for work which cannot be denied. What was shown and seen during the war proved that if women were carefully selected and placed under good conditions of work, they were, if not superior, certainly equal to men when it was a question of light work. Opinion varies as to the somatic differences of the two sexes: length of limbs, trunk, etc. What is certain is that woman being built on a different model from man, the particularities of structure and activity affect the organs the function of which is of prime importance for the future of the race. She is, as Montessori has said, above all and especially "the toiler of the species".

The article "Children" shows what are the differences in the development between boys and girls so far as height and weight are concerned. As to strength, when weight and height are equal a woman possesses rather more than half that of a man, and her output comes to about three-quarters that of a man.

According to the values obtained by Joteyko, the index of strength (as shown by the dynamometer) of women is \( \frac{570}{1,000} \) that of man; the index of resistance (by the ergograph) is \( \frac{670}{1,000} \).

According to Joteyko, in women the power of resistance is superior to the power of muscular effort. She is more apt at yielding a moderate effort than at giving a single big one. With the same height the respiratory capacity of man is one-third to one-fourth greater than that of woman.

The respiration, pulse-rate, composition of the blood, etc., which even in the normal woman differ from those of man, show more marked variation during pregnancy. This exercises, especially during the later months, noticeable compression on the heart, a diminution of the amplitude of the respiratory movements, a retardation in nutrition, a diminution of muscular power, a certain difficulty in the circulation of the blood, and a greater susceptibility to toxic and infectious agents. While certain autho-
rarties (Collis, Joteyko) hold that these
differences are due less to woman's
native constitution than to a failure of
physical power due to social habits of
life, there is no question that in practice
women are excluded from industries
involving heavy labour.

From the point of view of psychical
activity, there is no difference in degree
of intellectuality or of brain power in
quantity, but rather in quality: the
working of the brain in men and
women is not identical (Amar). On the
other hand, woman submits readily to
industrial discipline, adapts herself
easily to a life in a narrow atmosphere,
as well as to work which calls for rela-
tive immobility, looks after detail, har-
mony of forms, has a great deal of
patience (Rubino), etc., so that she is
due to the failure of
authorities would allow the favourable
influence of work with increased physi-
cal activity, while menstruation is said
to become more regular and less pain-
ful. This opinion, expressed by Ramaz-
ini, as based on facts obtained from
weavers, seems to break down as the
result of numerous recent observations
(Great Britain, United States). It does
not seem as though the duration of
work can be directly blamed because it
is the position in which work is done
(sitting, or prolonged standing, walking
or tramping, continuously, vibrations
over the pelvic regions, knocks, direct
friction over the abdomen, etc.)
which produce menstrual troubles (dysmenor-
roha, amenorrhoea, menorrhagia).

While a standing position is tiring,
a sitting one which is prolonged is still
worse (as it causes passive congestion
of the organs in the pelvic basin; tend-
cency to constipation). Obviously, alter-
ation of the two positions is the best,
and, as a matter of fact, in cases where
this alternation is possible, the number
of cases of absence due to dysmenor-
roha have fallen 50 per cent. as com-
pared with those occupations where
women have to sit constantly (Mock).

Women employed in foot pedalling
present more marked troubles: 15.7 per
cent. for sewing as compared with 3.5
per cent. for those sewing by hand (Leh-
mann).

A prolonged upright position with con-
tinual tramping, such as is observed
among ironers, predisposes noticeably
to dysmenorrhoea (30 per cent.: Falk),
to profuse menses, displacements of pel-
vic organs (retroflexion, prolapse, etc.).

(b) The external factors, cold, heat,
confined air, vitiated air, etc., awkward
work or work carried on under awk-
ward conditions (as, for example, by
washerwomen), favour the development
of particular maladies and arrest of
menstruation.

Opinion differs as to the lesser resis-
tance of woman to the action of poisons1.

But to glance through the literature
(on lead poisoning especially), suffice
to discover the data — all too abundant —
on the lesser resistance of woman to the
action of lead and its compounds.

1 For industrial poisoning among women work-
ers, cf. the recent work of Frois (see Bibli-
ography at end of article).
WOMEN'S WORK

Observations made in Great Britain among women employed in white lead factories and pottery manufacture have shown that they succumbed more quickly than men to poisoning and had more severe symptoms (Oliver). This expert has been led to the conclusion that women are more susceptible than men to the action of lead, and that this susceptibility was already great between eighteen and twenty-three years of age, while in men symptoms developed at a later age.

When economic conditions of life were equal, poisoning was higher among men. Hamilton, however, has to admit that symptoms in the two sexes are different and that chronic constipation, anaemia and menstrual troubles due to lead do not appear in statistics as occupational diseases of women; whence perhaps the reason of this so-called lesser frequency of poisoning. The incidence of lead poisoning is certainly greater among women than among men, for men employed in pottery paid, were 56.7 cases per 100 men as against 28.6 per 100 women and 20 per 100 men. The men, too, it should be remembered were those rejected from military service, while the women were in good health. In 1916, at Düsseldorf, there were 66.7 cases per 100 men as against 66 per 100 women. When, in 1918, the blockade aggravated the food conditions, the rate exceeded 100.5 in the case of men and 119 in that of women.

In Great Britain, women were found so susceptible to the action of sulphuric ether as used in smokeless explosive factories that men had to be substituted for them.

The same fact was brought out in the United States. The majority of these poisons, and of lead particularly, induce quite a series of troubles in the generative organs which they derange both functionally and organically: irregular menstruation, amenorrhoea, anaphrodisia, inability to conceive, etc. These troubles often follow general ill-health: anaemia, chlorosis, due themselves to occupational influences.

Fertility — Pregnancy

Without entering into details of the difficult and vexed question of the low-

<table>
<thead>
<tr>
<th>Duration of exposure</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colic</td>
<td>4.89 per cent.</td>
<td>10.3 per cent.</td>
</tr>
<tr>
<td>Paralysis</td>
<td>5.0 per cent.</td>
<td>6.3 per cent.</td>
</tr>
<tr>
<td>Convulsions</td>
<td>15.0 per cent.</td>
<td>22.3 per cent.</td>
</tr>
<tr>
<td>Blindness (total)</td>
<td>9.8 per cent.</td>
<td>12.3 per cent.</td>
</tr>
<tr>
<td>Blindness (partial)</td>
<td>3.5 per cent.</td>
<td>10.2 per cent.</td>
</tr>
</tbody>
</table>

In American potteries Hamilton found saturnine encephalopathy among one out of 17 cases of lead poisoning in men and one out of 4.5 cases of lead poisoning in women.

Curschmann, Loewy and others, have for a long time insisted on this lessened resistance and on the very strong reaction of the female generative organs to industrial poisons. Experience demonstrates this lessened resistance to nitro and amido derivatives of benzene (as, for example, the experience in England during the war with trinitrotoluene, carbon bisulphide, etc.). Recent unhappy experience has brought into relief the sensitiveness of women to benzene: serious haemorrhages, fatal menorrhagia (see article "Benzene") also were found to be more two months.

During the war the same facts were in evidence with regard to trinitrotoluene which affected the workers of munition factories in a proportion of 28.6 per 100 women and 20 per 100 men. The men, too, should be remembered were those rejected from military service, while the women were in good health. In 1916, at Düsseldorf, there were 66.7 cases per 100 men as against 66 per 100 women. When, in 1918, the blockade aggravated the food conditions, the rate exceeded 100.5 in the case of men and 119 in that of women.

In Great Britain, women were found so susceptible to the action of sulphuric ether as used in smokeless explosive factories that men had to be substituted for them.

The same fact was brought out in the United States. The majority of these poisons, and of lead particularly, induce quite a series of troubles in the generative organs which they derange both functionally and organically: irregular menstruation, amenorrhoea, anaphrodisia, inability to conceive, etc. These troubles often follow general ill-health: anaemia, chlorosis, due themselves to occupational influences.

Fertility — Pregnancy

Without entering into details of the difficult and vexed question of the low-
ered birth-rate noticeable to-day in all great industrial centres, it must be re-
recognised that this fall particularly af-
facts the working class. Thus, for ex-
ample, the fall in the birth-rate, which
was 18.5 per cent. for the city of Berlin,
reached a rate of 21.1 to 30 per cent. in
the working class areas (Siberglerit).
In ten English towns the birth-rate has
fallen between 1881 and 1901, especially
where there was a large number of mar-
rried women workers (Sydney Webb).

In an industrial town like Blackburn
the birth-rate was found to be in strict
relation with the number of industrially
employed women. Thus (after correc-
tion for age) the percentages of fertility
in women as follows:

<table>
<thead>
<tr>
<th></th>
<th>Women not employed</th>
<th>Working women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.3</td>
<td>3.0 to 3.6</td>
</tr>
<tr>
<td>Average</td>
<td>3.8</td>
<td></td>
</tr>
</tbody>
</table>

The preliminary enquiry made in
Italy for maternal assurance brought
out the birth-rate values shown in the
accompanying table (page 1242).

Although assuredly the actual fall in
births is partly accounted for by a vol-
untary factor, it is not right to under-
estimate the importance of the factor
of female fertility. Even among the
agricultural population, according to
Hirsch, a fall in the birth-rate is found
due to the nature of the work carried on
(intensity and duration of the physical
efforts demanded without taking account
of hours, temperature, etc.), and this
effect on fecundity is more serious
in women employed in mines and un-
healthy industries.

Gestation, parturition and the puerpe-
ral period generally are also influenced
by occupation. Obviously, the physi-
ological changes which take place in
the organism in the course of pregnancy
in a working woman leads to the con-
clusion that "the pregnant woman
suffers from her surroundings, which
in turn are none the better for her
presence" (Vicarelli). The intimate
relations between pregnancy and the
organism are affected by the factors
which act mechanically (position
assumed at work) or biologically
(poisons). On the other hand, accord-
ing to certain authorities, industrial
work does not to-day seriously af-
fact the normal course of pregnancy,
because women are excluded from un-
healthy trades or, when pregnant, they
abandon work of their own accord, or
are dismissed at a more or less advan-
ced period of their pregnancy, either as
a consequence of statutory requirements
or the improvement in the economic and
social conditions of the working class
(Vicarelli). On the other hand, it should
not be forgotten that too many working
women still ignore to-day the fact that
pregnancy, even when normal, should
be specially safeguarded and that preg-
nant women should not work longer
than they can properly do, only call-
ing in the doctor at the moment of child-
birth or in case of grave troubles. Ac-
cording to Hirsch, this fact explains why
maternity troubles in general, and preg-
nancy in particular, furnish the great-
est contingent of sickness in German
working women, and why the patholo-
gical conditions caused by employment
in pregnant women render them unable
so frequently to conceive later or render
them incapable, sometimes permanently,
to gain a remunerative livelihood.

The figures of the Leipzig Sickness
Insurance Society are very interesting
on this subject.

Of 100 accouchement cases there were:

<table>
<thead>
<tr>
<th></th>
<th>Voluntarily Insured</th>
<th>Compulsorily Insured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscarriages</td>
<td>0.20</td>
<td>0.60</td>
</tr>
<tr>
<td>Premature births</td>
<td>0.30</td>
<td>0.60</td>
</tr>
<tr>
<td>Diseases of pregnancy</td>
<td>0.10</td>
<td>0.30</td>
</tr>
<tr>
<td>Deaths in childbirth</td>
<td>0.25</td>
<td>0.29</td>
</tr>
<tr>
<td>Accidents during childbed</td>
<td>10.58</td>
<td>11.66</td>
</tr>
</tbody>
</table>

The Union of German Textile Workers
has proved that of 1,110 cases of ac-
couchement at full term, 300 were nor-
mal and 801 (72.16 per cent.) pathological
— due partly to the frequency of con-
tracted pelvis induced by admission to
labour of girls at too young an age.
All the complications of gestation:
miscarriages, abnormal presentations,
preadterm rupture of membranes,
"placenta praevia", toxaemias of
pregnancy, eclampsia, psychoses, etc.,
as well as varicose veins of the vulva
and legs, and haemorrhages, are very
frequent, so various authorities state,
and very severe among working women.
At the same time, miscarriage and
premature confinement which are, so
far as the obstetrical pathology of the
working mother is concerned, the most
frequent clinical forms assumed, are
rarely thought (Vicarelli) to be ascribed
solely to "industrial work". Ac-
count must be taken of other concomi-
tant injurious and morbid causes such
as organic weakness, congenital or
hereditary, inappropriate treatment or
improper upbringing in childhood,
constitutional or venereal diseases,
unhealthy living, prostitution, alcoholism,
etc.

According to Vicarelli, while the work-
ing woman in certain occupations is
subjected to arduous work and some-
times to injury or vicious attitudes capa-
cible of menacing or compromising the
normal course of pregnancy, this occurs
relatively rarely because the pregnant
woman generally gives up her occupa-
## Number of Full-time Workers and Parturient Workers

### Distribution by Age Groups of Full-time Women Workers and Parturient Women Workers

<table>
<thead>
<tr>
<th>Industry</th>
<th>Number of Premises Observed</th>
<th>Number of Women Workers</th>
<th>Corresponding Number of Full-time Workers</th>
<th>Number of Confine- ments in the Year</th>
<th>Number of Married Women per 100 Women Observed</th>
<th>Number of Confine- ments per 100 Women Observed</th>
<th>Parturient</th>
<th>Parturient per 100 Full-time Women Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2,802</td>
<td>191,947</td>
<td>172,149</td>
<td>7,672</td>
<td>27.5</td>
<td>4.5</td>
<td>67,828</td>
<td>70,261</td>
</tr>
<tr>
<td>Agricultural Industries</td>
<td>25</td>
<td>835</td>
<td>555</td>
<td>193</td>
<td>41</td>
<td>34.8</td>
<td>161</td>
<td>295</td>
</tr>
<tr>
<td>Quarries and mines</td>
<td>76</td>
<td>1,800</td>
<td>1,536</td>
<td>290</td>
<td>32</td>
<td>21.3</td>
<td>658</td>
<td>633</td>
</tr>
<tr>
<td>Metallurgy, metal construction and construction of machines</td>
<td>100</td>
<td>1,938</td>
<td>1,540</td>
<td>332</td>
<td>68</td>
<td>21.6</td>
<td>618</td>
<td>784</td>
</tr>
<tr>
<td>Woodworking, working of straw</td>
<td>64</td>
<td>2,102</td>
<td>1,702</td>
<td>516</td>
<td>85</td>
<td>22.3</td>
<td>778</td>
<td>828</td>
</tr>
<tr>
<td>Chemical Industries</td>
<td>88</td>
<td>5,565</td>
<td>5,017</td>
<td>2,515</td>
<td>220</td>
<td>4.7</td>
<td>778</td>
<td>828</td>
</tr>
<tr>
<td>Paper and polygraphic industry</td>
<td>305</td>
<td>5,508</td>
<td>4,799</td>
<td>1,580</td>
<td>215</td>
<td>3.3</td>
<td>1,674</td>
<td>2,199</td>
</tr>
<tr>
<td>Textile Industries</td>
<td>1,758</td>
<td>152,295</td>
<td>137,416</td>
<td>39,870</td>
<td>5,279</td>
<td>24.0</td>
<td>57,085</td>
<td>67,712</td>
</tr>
<tr>
<td>Animal waste, clothing and tailoring and similar industries</td>
<td>264</td>
<td>8,481</td>
<td>6,895</td>
<td>2,070</td>
<td>385</td>
<td>20.9</td>
<td>2,651</td>
<td>3,409</td>
</tr>
<tr>
<td>Food Industry</td>
<td>91</td>
<td>1,658</td>
<td>1,329</td>
<td>446</td>
<td>49</td>
<td>3.6</td>
<td>473</td>
<td>631</td>
</tr>
<tr>
<td>Tobacco Industry</td>
<td>16</td>
<td>10,339</td>
<td>10,446</td>
<td>6,599</td>
<td>1,087</td>
<td>10.6</td>
<td>1,402</td>
<td>4,602</td>
</tr>
<tr>
<td>Other Industries</td>
<td>22</td>
<td>1,076</td>
<td>909</td>
<td>536</td>
<td>48</td>
<td>50.0</td>
<td>156</td>
<td>254</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Full-time workers</th>
<th>Parturient</th>
<th>Parturient per 100 Full-time Women Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-20 years</td>
<td>67,828</td>
<td>190</td>
<td>0.3</td>
</tr>
<tr>
<td>20-25 years</td>
<td>70,261</td>
<td>6,637</td>
<td>8.4</td>
</tr>
<tr>
<td>25-35 years</td>
<td>25,060</td>
<td>35</td>
<td>3.4</td>
</tr>
<tr>
<td>35-50 years</td>
<td>10,632</td>
<td>109</td>
<td>—</td>
</tr>
</tbody>
</table>

*Note: The numbers represent the distribution of full-time workers and parturient workers by age group*
tion or, if she goes on with it, does so with greater care and prudence.

The same physical factors which affect the catamenial function may also interfere with pregnancy. In some trades these factors are more powerful than in others. Thus, for example, a bent position, with the body crouched, combined with heat and moisture, lead to metrorrhagia, miscarriage, prema-

extension, stretching out and drawing back, sometimes rapidly repeated in order to follow the rhythm of the machine demanded today of the worker in a textile mill; it is sufficient to realise the bending, the twisting, the leaning forward necessitated by the requirements of the machine, and that the woman must often have to lift, drag or push heavy loads, to appreciate how 

![A pregnant woman at work in a German jute-spinning mill.](image)

The position assumed at work gives rise to pregnancy troubles in seamstresses, textile workers, and in women employed in transport, etc. It suffices to recall the whole series of movements of the body of the woman is obliged to sustain shocks, blows and bruises which naturally affect the foetus.

Bonnaire distinguishes three occupational attitudes of the pregnant woman corresponding to the postures: vertical without movement, vertical combined with locomotion, and sitting. He considers the continuous upright attitude
without movement is always unfavourable for the expectant mother; less trying is the upright station with locomotion, although this does not eliminate fatigue. If not carried to excess walking maintains the suppleness of the body, thanks to the intimate massage of the tissues and the stimulation of the venous circulation which helps in the play of the muscles. Often a woman who has been long standing feels more refreshed after a little walking than after sitting. Of the three attitudes, that which best responds to the needs of industrial hygiene for the expectant mother is sitting, especially when walking from time to time can be combined with it.

Accidents at work, and particularly those of a traumatic nature, may have very severe consequences, such as intra-uterine fracture on the head of the foetus, rupture of the amniotic sac, etc. Among external factors which, in the course of work, constitute an indirect source of injury to pregnant women are dusty trades and the textile industries, in which it is frequently possible to observe that respiratory troubles are aggravated by the maternal state, constituting a menace to pregnancy in its turn; the unhealthy or poisonous industries, affecting the hepato-renal system or the blood, directly interfere with the normal course of gestation, etc. The woman worker, with her organs of elimination already weakened when she has become pregnant, succumbs more easily and more severely to the auto-intoxications of pregnancy.

Fig. 200. — A pregnant woman at work in a German silk-weaving mill.
To show the influence of intellectual work on pregnancy is more difficult, as the majority of women employed as secretaries, school mistresses, etc., are usually confined at home—a fact which interferes with the collection of data. Although biology and experimental psychology show that intellectual overwork brings about modifications either of the organs of vegetative life or organic changes, it can be said at the same time that these women, in spite of work often carried out under rather unhygienic conditions, and in difficult circumstances, combined with defective and inappropriate diet, are rarely endangered by pregnancy. On the other hand, intellectual women workers, already the subjects of some weakness and a certain amount of excitement of the nervous system, pass through the stage of pregnancy with a high degree of nervousness and increased reflexes which are accentuated by greater intolerance and hyperaesthesia of the uterus (Vicarelli).

**Sequelae of Confinements**

Occupation influences also the sequelae of a confinement and increases mor-

Fig. 301 — A pregnant woman at work in a German jute-twisting mill.
tion of the uterus, uterine or vaginal prolapse, sterility, miscarriages, etc.

Sufficient rest is all the more indispensable as early getting about may lead to haemorrhage or "post partum" embolism. This is why international agreement was reached as to compulsory rest after confinement.

Work of the Mother and her Offspring

A whole series of observations show the influence of the parents, and of the mother in particular, on her offspring. The absence of rest before confinement and the nature of the work done by the mother, besides other factors to which reference has been made above, give to the offspring in working-class families from the time of their birth the stamp of physical defect. It is noticeable that the average weight of the foetus rises as the social conditions of the mother improve, and that the percentage of foetuses of a weight below the average in women of different social status is so much the lower as conditions are better.

Allaria has shown that the average weight of the newly born infants of mothers employed in factories is below that of infants of other working women. He gives the following figures:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Grm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housekeepers</td>
<td>3,100</td>
</tr>
<tr>
<td>Peasants</td>
<td>3,050</td>
</tr>
<tr>
<td>General servants</td>
<td>2,950</td>
</tr>
<tr>
<td>Working women</td>
<td>2,950</td>
</tr>
<tr>
<td>Factory workers</td>
<td>2,900</td>
</tr>
</tbody>
</table>

Analysis of 18,865 confinements in the clinics and hospitals of Rome, during the period 1912-1918 gave the following values for the weights of newly born infants of working mothers.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Grm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurses</td>
<td>Upwards of 3,500</td>
</tr>
<tr>
<td>Peasants, chambermaids, cooks, market women, laundromaid</td>
<td>3,200-3,300</td>
</tr>
<tr>
<td>Artists, maids, caretakers, seamstresses</td>
<td>3,100-3,200</td>
</tr>
<tr>
<td>Ironers, clerks, housekeepers, sweepers</td>
<td>3,000-3,100</td>
</tr>
<tr>
<td>Women printers</td>
<td>2,950</td>
</tr>
<tr>
<td>Machinists</td>
<td>2,850</td>
</tr>
<tr>
<td>Tramway conductors</td>
<td>2,304</td>
</tr>
</tbody>
</table>

According as the mother is accustomed to hard or light work, so the weight of the newly born varies equally. Thus, for example, seamstresses and corset makers working with sewing machines have weaker children than those having lighter work at which they sit; agricultural labourers who, owing to their strong constitution, ought to have vigorous children frequently have children below the average. At the same time the children of housekeepers, of women engaged on sedentary work, among whom the relative immobility of the body during work favours a longer duration of pregnancy, as well as those of multipara, are better developed, heavier and longer.

This rule has its exceptions which affects women employed in unhealthy industries. Thus, Frongia has found that 90 per cent. of full-term pregnancies of workers in the mines of Sardinia result in cachectic children, 30 per cent. of whom die in the first months or years; of those who reach twenty years of age 90 to 95 per cent. are unfit for military service (see Bibliography).

An adequate period of rest enables the foetus to become of average weight, and this increase is so much the more marked as the period of rest before lying-in is prolonged. Vicarelli has shown that the weight of the newly born in fact increases on an average 62 grm. after a rest of ten days; 238 grm. after a rest of twenty days, 246 after thirty days and 412 grm. after forty days (see Bibliography).

Merletti gives somewhat different figures; but account must be had of other factors which play an important role in this question, such as the legitimacy or illegitimacy of the pregnancy. Illegitimate pregnancies often modifying profoundly the development and weight of the child, which does not always respond to the compensatory advantages of long attendance at a clinic. That a rest of some weeks before confinement suffices to improve the weight of the child is proved by a whole series of data. Thus the infants of persons living a retired life are usually in excellent condition. Bazin has said with reason that "women factory workers are the devourers of men", and Alfieri, more recently, that from the material and moral point of view, "maternity and factory work are antithetic terms".

These facts being recognised, it is not to be wondered at that infantile mortality increases amongst the children of women employed on industrial work. As early as 1908 an enquiry made by the Humanitarian Society of Milan showed that working-class families had the lowest percentage of living infants and that working women who were mothers had the highest percentage of stillbirths. The enquiry by Woodbury (1925) relating to 22,967 children at nurse, made in eight towns in the United States, brought out the fact that children of less than a year whose mothers were employed away from home had a mortality 2.5 times as great as those whose mothers were employed at home. Similarly, the mortality rate in the first year of life was 9.8 per cent. for children whose mothers had not been employed during confinement, 11.46 per
cent. for those whose mothers had been engaged in home work, and 17.61 per cent. for children whose mothers had worked during pregnancy. This serious situation is reflected on the whole population, because, according to the statistics of Prinzing, Newsholme, etc., the general infantile mortality increases on parallel lines with increase in industrial employment of women.

Newsholme gives the following figures for Great Britain:

<table>
<thead>
<tr>
<th>Number of women employed in industry</th>
<th>Deaths in the first year for 100 infants born alive in Staffordshire towns</th>
<th>Whole of Great Britain, 1881-1890</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10 per cent.</td>
<td>15.2</td>
<td>15.4</td>
</tr>
<tr>
<td>From 10 to 15 per cent.</td>
<td>16.6</td>
<td>17.1</td>
</tr>
<tr>
<td>Above 15 per cent.</td>
<td>19.5</td>
<td>17.5</td>
</tr>
</tbody>
</table>

Those who do not accept the importance of the factor of "employment" consider that account must be taken of "poverty" in the case of the woman and of the household in general in order to explain the infantile mortality amongst the working classes.

Greenwood, Brown, Rochester (of Baltimore), and others do not consider there is direct relation between "poverty" of the mother and infantile mortality. When crises occur (strikes, lockouts), the infantile mortality in industrial districts is not influenced. This is what has been found in Great Britain (1912), France, etc., where during a period of very great demand for female hand labour the general mortality rate has not varied; but, on the other hand, the infantile mortality rate has considerably increased as the children have been uncared for and have been without supervision from their mothers engaged in the mills.

In social depression in Lancashire an increase in the general mortality rate has been observed as the result of the hardships met with; on the contrary, there has been diminution in the infantile mortality rate because the mothers had little to do but to act as nurses and devoted themselves more to their children.

Similarly, infantile mortality varies very little according to the different social classes. Thus, for example, Forbes, of Brighton, made out the following mortality (per thousand births):

<table>
<thead>
<tr>
<th></th>
<th>Illegitimate children</th>
<th>Poor families</th>
<th>Working class families</th>
<th>Middle class families</th>
</tr>
</thead>
<tbody>
<tr>
<td>First week</td>
<td>27.1</td>
<td>18.7</td>
<td>31.5</td>
<td>27.7</td>
</tr>
<tr>
<td>First month</td>
<td>48.0</td>
<td>33.1</td>
<td>30.1</td>
<td>27.7</td>
</tr>
</tbody>
</table>

Raffaelli (1924) cites the following data in regard to 1,000 births (Westminster, 1907-1908): Infantile mortality, therefore, depends not only on the social and hygienic conditions in which the mothers are placed during the time of pregnancy, but also on maternal care (Salisbury Hughes, 1925). This is also the opinion of Sir George Newman, who has written as follows: "Poverty alone is not responsible for infant mortality, because it is low in certain very poor districts. Housing and external environment are also not responsible. Infant mortality is on the contrary in strict relationship with certain conditions of the social life of the population."

In 1858 English opinion was that infants died because of maternal neglect. During the war many women were employed in factories and the infant mortality rate was not increased because a good system of infant welfare was organised.

The enquiry of the Women's Industrial Council of the United States (1917) did not bring out noticeable differences between the infant mortality and birth-rate of mothers of the housekeeping class and working women. Other enquiries, however, have yielded very different results: in France, in Belgium, and in the Netherlands, the death-rate of infants of working-class mothers was double the average. Other factors must play their part here, such as housing conditions, density of population, etc. Nor should the lessened resistance to disease of these infants — already born less in weight than the average — be forgotten. Couvelaire, Schauta, Léopold, Resinelli, etc., have contributed to the knowledge of this fact of great so-
cial importance. Pinard has said: "Everything which removes the child from its mother places it in a state of suffering and in danger of death. Nothing can ever replace the heart and milk of a mother." The more recent statistics published for Great Britain and other industrial countries lead to the same conclusions.

The increase in this mortality then has a relation to different causes of a infant mortality rate in the first year of life to be 16.93 per cent. among the children of mothers who had given up work a month or more before confinement, 18.75 per cent. when the mother had given up work for less than a month, 24.41 when she had continued work up to the time of her confinement. Similarly, in regard to the excessive mortality of nursing infants in their first year of life, the enquiry in question showed

Fig. 202. — A pregnant woman at work in a German cloth-weaving mill.

general and special kind. Of the first it will suffice to cite the lack of rest for the mother before her confinement; the continuation of work afterwards; resumption of work depriving the child of milk and maternal care; the bad method of bringing up nurseries (digestive troubles, etc.). Thus Woodbury's enquiry in America showed the that the children of mothers who resumed work less than two months after childbirth showed a mortality three times as great as the average.

Among the special causes, the nature of the occupation carried on by the mother is of import, these trades offering a risk of poisoning being particularly detrimental. As a matter of fact, the
poison absorbed by the maternal organism passes through the placental circulation directly to the foetus. Lead, phosphorus, arsenic, bromine, chlorate of potash, etc., are known to pass through the placenta and set up very severe lesions. Mercury does not pass through the placenta, but accumulates there in abundance. Phosphorus sets up placental haemorrhages which permit of intoxication of the foetus where even an hepatic steatosis has been found. The alkaloids also reach the foetus on which they confer a certain power of resistance to the action of these poisons.

The effect on the product of conception of chronic poisoning by alcohol, lead, mercury, etc., is notorious; they cause notably miscarriages, or still-births, or debilitated infants which develop badly and are likely to die young. Carbon monoxide reaches the blood of the foetus which, however, contains less than that of the mother; the quantity of lead also varies, but generally it is very small, etc. Elimination takes place especially through the placenta, because the amniotic fluid does not contain it; similarly it is not found in the urine of the foetus collected at the moment of birth. Researches show that the foetus is more resistant than the adult to certain poisons, as, for example, nerve poisons — a fact explained by the poor development of the nervous centres of the foetus. If death comes it is due to mechanical troubles in the placental circulation: lowering of the blood pressure of the mother (carbon monoxide, carbon dioxide, chloroform, etc.), whence arise miscarriages.

For long no doubt has existed that lead poisoning of the parents is a cause of injury to the life of the foetus and provokes morbid changes or induces death. Enquiries by specialists on this point are numerous, and it will suffice to recall the work done by Hamilton (Industrial Poisons in the United States, p. 110: "Lead as a Race Poison") and other contributions by Devoto, Teleky, Olivier, etc.

Dineufbourg (1905 thesis) gives particulars of observations on women classified as follows: (a) those whose husbands were engaged in lead employment without being themselves exposed to contact with lead; (b) women who formerly were exposed to the risk of lead poisoning but whose husbands were not in contact with lead; and lastly (c) women previously in contact with lead and whose husbands were employed in lead industries.

The ratios fall as follows:

<table>
<thead>
<tr>
<th>In contact with lead</th>
<th>Number of pregnancies</th>
<th>Miscarriage</th>
<th>Stillbirths</th>
<th>Percentage</th>
<th>Born alive of 100 living in the first year</th>
<th>Percentage of 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father only</td>
<td>442</td>
<td>68</td>
<td>47</td>
<td>23.5</td>
<td>309</td>
<td>74.4</td>
</tr>
<tr>
<td>Mother only</td>
<td>134</td>
<td>17</td>
<td>11</td>
<td>17.0</td>
<td>111</td>
<td>73.9</td>
</tr>
<tr>
<td>Both</td>
<td>33</td>
<td>4</td>
<td>4</td>
<td>35.0</td>
<td>15</td>
<td>66.6</td>
</tr>
</tbody>
</table>

Lead poisoning on the paternal side is also as disastrous from this point of view as lead poisoning on the maternal. While Dineufbourg's figures for the two last groups are rather too small to draw conclusions from, other researches can be cited which seem conclusive. Thus, for example, Reid found in the case of 100 women:

<table>
<thead>
<tr>
<th>Miscarriages and still-births</th>
<th>Deaths in the first year per 1,000 born</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housewives</td>
<td>43.2</td>
</tr>
<tr>
<td>Factory workers (not using lead) before marriage</td>
<td>47.6</td>
</tr>
<tr>
<td>Factory workers (using lead) before marriage</td>
<td>86.0</td>
</tr>
<tr>
<td>Factory workers (using lead) after marriage</td>
<td>125.5</td>
</tr>
</tbody>
</table>

This proves that the factor "Factory Work" alone aggravates the infantile mortality in the first year of life and that contact with lead aggravates the incidence of miscarriages and of still-births.

Oliver has shown experimentally the destructive action of lead on the embryo and foetus. This action is so notorious that salts of lead are used by people lacking medical knowledge as abortifacients.

As early as 1860 Paul formed the opinion that the abortifacient action of lead was more important than syphilis, and since then a number of statistical enquiries have shown the correctness of this view.

The available data show that the longer the poisoning has lasted, the more profoundly is the mother intoxicated...
and the more dangerous are the pathological conditions of pregnancy. On the other hand, if the poisoning is not very marked and if the woman gives up her unhealthy work at the commencement of her pregnancy (about the third month), the gestation may be a normal one. Similarly, it has been shown that normal confinements can follow on miscarriage if the woman gives up her unhealthy work, but that pathological pregnancies return on resumption. Premature confinements are also frequent, favoured by industrial fatigue, and especially under the influence of industrial poisons, particularly lead. Lead is said to kill one-half of the products of conception.

Frongia comes to almost the same conclusions (44.1 per cent.).

Mercury also causes miscarriages, a high infant mortality and serious injury to the child. Thus tremor has been observed in the children of mercurialised parents. Alcohol is a notoriously frequent cause of nervous accidents in the offspring of alcoholics.

Arduous work exercises a baleful influence, not only on the woman, but also on the products of conception (see article "Occupational Diseases: Loco-

![Fig. 203. A pregnant woman at work in a German jute-weaving mill.](image)

where the woman continues to work right up to the time of childbirth (24 per cent. in the case of women who have worked to the end of pregnancy as against 12.6 among those who have ceased work beforehand).

Devoto and his co-workers and Frongia have shown the great effect of lead poisoning in the father on the offspring. Carozzi brought out the fact that in 361 working-class families the fathers in which were working in lead, there were 1,418 conceptions of which 203 ended in miscarriages; 528 infants died at an early age and only 687 grew up.

motor System"). As to injuries due to the carrying of too heavy loads, it will be sufficient to mention Conrad’s statistics, which, as far back as 1870-1874, showed the frequency of stillbirths among women employed in arduous work (4.15 per cent. of births as against an average of 2.1 for all births among all social classes).

The serious incidence of mortality occurring among the children of the working class can also be traced in later years. Further, the children who survive up to the time of conscription exhibit signs of physical degeneration (rickets, scrofula, lymphatic diathesis, etc.).
Here also it is the consequence of the failure of maternal care rather than of poverty which plays the important part.

Mention has been made above of the influence of the work of the mother on breast feeding and the role this play in infantile mortality. This function of maternity should be insisted on as it completes maternity. To nourish or not to nourish a child at the breast is to influence favourably or otherwise the nursing. On the other hand, employment exercises an influence on the faculty of breast feeding which, in consequence, may have to be diminished or suppressed. Further, some poisonous substances may have a baleful effect on the health of the child, partly compensated for, however, by the fact that the capacity for breast feeding in these women is minimal and diminishes rapidly.

Where economic conditions require the mother to resume her work as soon as possible after her confinement, recourse must be had to artificial feeding. As a matter of fact, the available data indicate that women working away from home nurse their children much less than others.

The American enquiry already referred to relating to the first three months of life of 22,967 newly born infants showed that artificial feeding accounted for 51.4 per cent. of the months of life of the children whose mothers worked away from home and only 23.2 for mothers not in employment.

Statistics compiled by Marie Baum show that 63 per cent. of mothers who work away from home adopt artificial feeding as compared with 33 per cent. of mothers not in employment.

Special Pathology

The anatomical and physiological peculiarities of the female organism explain the differences between the general pathology of women and that of men. While the injuries caused by professional environment are the same for the two sexes those due to other factors (position adopted at work, movements of certain segments of the body, etc.) explain the clinical picture observed in women. Thus, for example, prolonged maintenance of the same position (upright, seated, bent) has a baleful influence on children and adolescents, who present not only troubles or arrest of development of certain tissues or systems, but even pathological changes (displacement of organs) of the generative system and various circulatory troubles (see article "Children"). It is unnecessary to insist on the injury caused by the maintenance of the position mentioned above. Industrial poisonings also raise very important questions. Mention has already been made of the greater frequency among women working under the same conditions as men of the incidence of poisoning. In addition to particular causes (menstruation, etc.), the fact must be admitted that a larger amount of poison comes into contact with a woman than a man because of her hair and clothes, which become a receptacle for poisonous dusts. It has been seen, too, that in addition to pregnancies reaching full term and producing infants more or less vigorous and resistant, quite a number end in miscarriages, premature confinements or stillbirths. Certainly all the other causes apart from employment which are capable of interrupting pregnancy (general or local diseases of the mother, injury to the ovum, embryo, etc.) and of leading to abortion or premature confinement ought not to be underestimated. These causes do not act to a greater extent in the case of working class women than in other women. But where an excessive number of miscarriages and premature confinements are noted among working women, it would be logical, apart from the effects of special cases of poisoning, to attribute them to too arduous or prolonged physical work up to full term, to the lifting of heavy loads, to blows, or to the effects of vibration, etc.

Fatigue and over-pressure of work, the result of too long or too arduous toil, are without doubt a greater cause of female sickness than poverty. This is why for a long time past the duration of employment of women and children has been limited. At the same time night work has also been prohibited or curtailed, its baleful influence on health and social life having been recognised. The fact that a woman who has worked all night has to attend to her domestic duties instead of resting cannot be overlooked and this increases her state of fatigue. During the war, in Great Britain the output of women in alternation night shifts was decidedly lower than that of women working in alternate fortnightly day and night shifts. The problem of fatigue and strain is of the first importance in relation to the question of heavy work, carrying of heavy loads and charges, by their direct or indirect effect on the female organism and particularly on the development of the chronic maladies of the sexual organs.

When women have habitually to carry heavy loads (e.g. in the country or mountainous districts), skeletal deformi-
ties are noted (of the vertebral column, lower limbs), alterations in the thoracic capacity and abdominal walls. Thus, for example, a broadening in the lumbar region of the spine in women who carry loads with crushing together of the vertebrae, bringing about diminution in height, deformity of the pelvic basin with harmful effects on the development of pregnancy. Occupational cramp of the lateral muscles of the neck, pains of the brachial plexus, sub-occipital nerves, moveable kidneys, cardiac and thyroid hypertrophy, etc., have been reported.

The question is of such importance that it has been made the subject of numerous enquiries, e.g. in Great Britain (Industrial Health Research Board) by Cathcart, Overton and Bedale, etc., in Germany by Atzler and Saupe, in Italy by Patrizi, who have enquired into the optimum weight which should be carried. (See article "Transport Industry": B. Porters, etc.)

A satisfactory explanation of the greater sensitiveness of women to fatigue is not easy. Opinion on the question is divided. It might be thought that work adapted to her strength would fatigue a woman proportionately less than a man; but a woman is not able to engage in efforts of strength or physical activities as intense as a man.

It has been seen that though women adapt themselves readily to monotonous work, they are very easily affected by the effects of nervous fatigue if the work calls for great intensity and especially when passing through the menstrual period, pregnancy and the after-effects of childbirth. The special conditions of woman’s work at home should not be forgotten. While marriage, household cares, and especially the need of looking after their children cause many women to cease working in the factory, it is true also that they often try to make up for it by work done at home. Wages made in this way are notoriously low and the women try to increase them by working long hours. This overwork, associated, as so often is the case, with the bad hygienic conditions under which the work is done, aggravates the ill-health of this class of worker.

Lastly, the role played by fatigue induced by household worries ought to be emphasised, especially among women carrying on daily work at the factory or workshop, and for whom the double effort constitutes an important cause of lessened organic resistance. A woman, and particularly the mother of a family, has not finished her job on leaving the workshop or office. Having to look after domestic matters, to see to the needs of her husband and children, she is obliged to go to bed late and get up in the morning early, so that her daily rest is almost always insufficient. This state of chronic overwork exerts its baleful influence not only on her own health, but also on that of her children owing to inadequate maternal care (see above).

The special pathology of women workers as compared with that of men shows itself in the figures furnished by the Leipzig Sickness Insurance Society (in rates per 10,000 members):

<table>
<thead>
<tr>
<th>Lesions</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locomotory system</td>
<td>928</td>
<td>984</td>
</tr>
<tr>
<td>Skin</td>
<td>491</td>
<td>474</td>
</tr>
<tr>
<td>Respiratory passages</td>
<td>392</td>
<td>481</td>
</tr>
<tr>
<td>Pulmonary tuberculosis</td>
<td>563</td>
<td>63</td>
</tr>
<tr>
<td>Confinements</td>
<td>—</td>
<td>114</td>
</tr>
<tr>
<td>Confinements</td>
<td>77</td>
<td>63</td>
</tr>
<tr>
<td>Puerperal fever</td>
<td>—</td>
<td>3</td>
</tr>
<tr>
<td>General constitutional diseases</td>
<td>90</td>
<td>701</td>
</tr>
<tr>
<td>Of which Anaemia accounted for</td>
<td>98</td>
<td>676</td>
</tr>
<tr>
<td>Digestive system</td>
<td>692</td>
<td>876</td>
</tr>
<tr>
<td>Urogenital system</td>
<td>40</td>
<td>265</td>
</tr>
<tr>
<td>Benign tumours</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Circulatory system</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Nervous system</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Diseases of the sexual organs (not counting venereal diseases) are more frequent among women than men (255 as compared with 49 per 10,000 members); but these rates certainly do not give an exact picture of the situation. This excess is readily explained on thinking over the causes which might help to produce them (loss of menstrual blood — about 2 kg. per year — preg-
nancy, confinement, breast-nursing). Metritis and parametritis, for example, in 1915 represented among 150,000 members of the Munich Sickness Insurance Society 2.6 per cent. of all illnesses. Faulty positions are favoured by the arduous work and the upright position. Laubenburg (1916) found that such defects were three times more frequent among women working upright; Hamburger has brought out the fact that miscarriages are twice as frequent among working women as among those in easy circumstances (17.9 as compared with 8.2), etc.

Among the skeletal deformities of which mention has been made above, the most important are certainly those which affect the pelvic basin. Excessive and prolonged contraction of the muscles of the neck, of the dorsal and lumbar muscles, as well as of the muscles of the lower limbs which are inserted on the pelvis, influences its growth and subjects it, at a period of incomplete ossification, to a traction in a determined direction. The effect is so much the worse the more the worker suffers from latent or declared rickets and when the home conditions are bad. This is why rickets, osteomalacia, tuberculosis of the bones and joints, etc., enter into the aetiology of pelvic derangements so common among working-class women. The mechanical effects described above favour narrowing of the basin whence arise dystocia, difficult labour, increase in the frequency of instrumental intervention (forceps, caesarean sections, premature confinements or induced labour), and increase in the morbidity which has been referred to. To these pathological conditions are added, in young, poorly developed working women, a weakness of the soft parts (neck of the uterus, vagina and perineum).

The results found by Govoroff (1924) concerning the influence of occupations on the development of the female pelvis are given in the following tables.

<table>
<thead>
<tr>
<th>Working women</th>
<th>Number</th>
<th>Per cent. with contracted pelvis</th>
<th>Per cent. with pathological confinements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mines</td>
<td>760</td>
<td>40.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Metallurgy</td>
<td>570</td>
<td>29.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Various jobs</td>
<td>750</td>
<td>17.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Agriculture</td>
<td>550</td>
<td>19.0</td>
<td>2.5</td>
</tr>
<tr>
<td>No physical activity</td>
<td>450</td>
<td>8.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work commenced at age of</th>
<th>Mines and Metallurgy</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Retracted pelvis</td>
</tr>
<tr>
<td>11-12 years</td>
<td>25</td>
<td>90.0</td>
</tr>
<tr>
<td>13-14</td>
<td>65</td>
<td>75.0</td>
</tr>
<tr>
<td>15-16</td>
<td>400</td>
<td>31.0</td>
</tr>
<tr>
<td>16 and over</td>
<td>800</td>
<td>15.0</td>
</tr>
</tbody>
</table>

Okunjewa, Steinbach and Schtcheglowa studied in 1927 the effect of weight carrying among 1,450 persons (women) employed in different professions: peat, coal, metallurgical industry, etc. As a control, textile workers and tramway conductors in Moscow were selected. The lifting and carrying of weights give rise to lesion of the sexual organs: menstrual troubles 65.5 to 76 per cent. as against 26.5 to 39.2 per cent. among the controls. It should be noted that these troubles are most frequent especially for the age group 19-25 years (peat workers) and that the incidence diminishes the longer they have been at the work.

Among metallurgical workers, dysmenorrhoea and menorrhagia are very frequent (61 and 17 per cent.); among coal workers, dysmenorrhoea (69.3 per cent.); among peat workers, amenorrhoea (37.5). The worst cases were found among multipara and those who had had miscarriages: haemorrhages, prolapse troubles connected with preg-
nancy, etc. Enquiry showed that these lesions were in direct proportion to the amount of occupational work.

Politi and Flamini, of the Rome Obstetrical Clinic, found a higher rate of eclampsia among ironers, textile workers and compositors (from excessive work).

The attitude assumed plays an important role; very bent (see article "Clothing Industry"); upright (premature confinement); very bent forwards (hindrance to the longitudinal expansion of the abdomen and favouring shoulder presentation); special employments; in the rice fields (see article "Rice"), which favours anteversion and lateroversion, dysmenorrhoea, amenorrhoea; transport (vibration among women employed as tramway conductors or working on sewing machines; carrying of baskets supported against the abdomen, etc.).

All the available data show that chlorosis, anaemia and tuberculosis are the diseases which affect the working women most. While recognising the full the part played in their development by bad general conditions of life (housing, food, clothing, etc.), as well as particular predisposition or susceptibility either hereditary or acquired, it is nevertheless often impossible not to recognise the prime importance of bad working conditions (lack of exercise, work in rooms that are confined, hot, humid, dusty or badly lit, fatigue, overwork, etc.). Overtime is one of the most frequent causes of chlorosis and anaemia, especially among women employed in dressmaking and in textile workshops; it is sufficiently high in paper factories, letter-press printing works, and chemical works. Those most affected are young people between fifteen and nineteen years of age who show an incapacity from anaemia and chlorosis fifteen times as high as workmen. Women above forty-nine years of age show incapacity from the same maladies only seven times as high as that of men of the same age.

The fact need not be insisted on that anaemia and chlorosis prepare a soil favourable to the development of all other diseases, especially tuberculosis. While the total morbidity from this disease is less frequent among women than men, the mortality of women is higher especially at early ages. As a matter of fact, the rate for men is 30.2 as against 33.5 for women; and is 22 as against 32 in the age group 15-19 years. This occupational effect, shown particularly at early ages, is brought out, among others, by the Prussian statistics, where the general mortality from tuberculosis has fallen from 21.13 per thousand in 1900 to 17.26 in 1906, while that of women between fifteen and twenty years of age has increased, in relation to the general mortality rate of this class, from 43.90 to 48.34 per cent. (Hirsch).

Women most exposed to risk are those employed in dusty industries, sorting of paper, rags, spinning and weaving of cotton, jute, hemp, the manufacture of brushes and brooms, etc. An enquiry by Ishihara (1915) on the frequency of tuberculosis among Japanese women working in the textile mills has shown that this is a very important social question in Japan. Further enquiry made by a medical inspector relating to 4,341 women in a western province of Japan, recruited in 1922 by textile factories of other provinces, showed that 62 (46.6 per cent.) did so on account of tuberculosis. Teruoka considers that this infection is a common end of female young persons in modern industry.

A great preventive effort was made by Ohira, Chief Medical Officer of the Tokyo Cotton Spinning Company, employing 40,000 persons. His method of selecting workers enabled him to reduce the annual mortality from tuberculosis from 20.1 to 13.2, 11.2 and 9.7 per 1,000. He tried also inoculation with a prophylactic autogen — a method which might well be thoroughly tested by experts.

Fatigue and overwork are the most frequent causes of tuberculosis among working women, who at first only suffer from a cold — the precursor of tuberculosis.

Statistics show an absence from work on account of colds in winter of 10-15 per cent. of the workpeople, and in summer a similar rate from affections of the digestive tract.

Beri-beri is also an occupational disease weighing heavily on industry in Japan. Its progress during the year shows a characteristic seasonal curve commencing in the first months of the year, reaching its maximum in summer, and then falling month by month up to the end of the year.

This incidence varies, however, in different districts according to the climate and the individual conditions of the workers in the matter of nourishment. But the summer maximal is attributable to fatigue as neither the hours of work nor its exacting nature are lessened.

The digestive troubles are most commonly due to a state of anaemia and it affects mostly women employed in sedentary work. On the other hand, an important role is played by insufficient or unsuitable food. These again depend on lack of time or inadequate accommodation for taking meals — especially the mid-day meal — poor wages, etc.
Among the most important maladies of the circulatory system are varicose veins in the leg, which are especially common in trades where the women have to assume a continuous upright position, and are favoured by the injuries to which they are exposed. These varicose veins sometimes constitute a serious infirmity becoming complicated by eczematous inflammation and ulceration, which are the most frequent as sweat and dust irritate them and lead to scratching. They may have their seat in the vulvar region with danger of breaking either at the moment of confinement or as the result of accident.

German statistics (1925) give the following values as to incidence of varicose veins among textile workers per 100 women:

- Working continuously in an upright position: 12.70
- Standing and treading: 4.04
- Sitting most of the time: 2.90
- Always seated: 0.00

When the work demands sustained attention and continuous effort, the development of nervous diseases (psychosis, neurasthenia, etc.) is increased.

The increase in the diseases of the sexual organs is strikingly favoured by certain factors such as sexual perversion, malthusianism, miscarriage (fairly frequent among the working classes), occupational work, etc. — an increase which may partly be more apparent than real, as improvement in gynaecological diagnosis must be taken into account. The utero-ovarian maladies and their complications physically are the most dangerous for family life, as they are so often associated with states of moral and nervous disequilibrium causing havoc with domestic tranquillity and peace. Under these conditions evidently industrial work exercises an especially harmful effect either in relation to the generative system or the general health of the woman.

Observations made by Gutzmann relating to 2,373 women in a Berlin hospital and 356 dressmakers employed on pedal sewing machines brought out the following facts:

<table>
<thead>
<tr>
<th></th>
<th>Among women in hospital</th>
<th>Among sewing machine workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflammation of the appendages</td>
<td>6.6</td>
<td>18.8</td>
</tr>
<tr>
<td>Perforations of the lower appendages</td>
<td>2.4</td>
<td>12.0</td>
</tr>
<tr>
<td>Inflammation of the uterus</td>
<td>11.0</td>
<td>21.0</td>
</tr>
<tr>
<td>Retroversions and retroflexions of the uterus</td>
<td>16.8</td>
<td>22.3</td>
</tr>
</tbody>
</table>

Strassmann found 18.8 per cent. of diseases of the appendages among women engaged on sewing machines as contrasted with 6.6 per cent. for other women; 21 per cent. diseases of the uterus as against 11 per cent.; 22.3 per cent. displacement of the uterus as against 15.8 per cent. The majority of these troubles are due to vicious attitudes assumed at work, injuries, fatigue, etc. Metritis and endometritis, prolapse, apart from other causes (venereal diseases, post-abortive or post-puerperal inflammations, infectious diseases, venereal excesses), find in fatigue a factor of great importance affecting women, both those who have or have not had children — those of feeble constitution, the anaemic, the chlorotic, the pretubercular, those employed in unhealthy and dusty occupations, those forced to maintain a fixed position, etc.

Prolapse, which normally is the result of repeated pregnancies or a difficult confinement, is recognised among working women as following on strain in all its forms. The weakening of the ligaments holding the uterus in position, (large ligaments, utero-sacral, etc.) and of the supporting pelvic floor is sufficient to cause it.

Where to the mechanical factor of labour are added the biological factors of repeated pregnancies, sometimes painful and laborious, the frequency of prolapses is explained in this occupational class. Prolapse, it should be noted, is met with less frequently among childless working women.

Peigney examined 800 women from workshops — some having to sit and others to stand. Among the childless he found anteversion of the uterus 45 times (normal 40), retroversion 25 (normal 25), and prolapse, once (1:800); and among women with children, anteversion in 30 (25), retroversion in 65 (40), and prolapse in 30 (10).

Women with tumours of the generative organs may notice the condition becoming aggravated under the influence of work. Lifting heavy weights, strain of every kind, shocks and vibration, may set up torsion round the neck of the cysts of the ovary, myomata of the uterus, etc., with all the usual pathological consequences. Further, general impoverishment of health, bad domestic conditions, food insufficient to repair the daily deficit, etc., favour cancerous degeneration of benign tumours of the uterus.

As regards accidents of work to women (in respect of susceptibility, etc.), the data are not very abundant. Pregnancy certainly increases the risk of accident, just as do certain moral or
psychological factors, more than in the case of men. The great increases in the number of women employed during the war in munition factories increased the number of accidents. Thus, for example, Thiele found that for 100 accidents which befell men, women had 47.6 in 1917 and 91.4 in 1918 in Germany. Here it must be remembered too that the conditions under which women did their work, unfamiliar as they were with the handling of dangerous tools, complicated machinery and lastly the guarding of machinery, often left much to be desired.

A question that has been raised quite recently is that of the relation of accidents and lesions of the genitals (Au-vray) when the region involved is the vulvoperineal. An injury might occur to the uterus and its appendages across the abdominal wall as the result of an escape of the pelvis involving concomitant injuries to the intestine or bladder. In certain cases the injury might cause inflammation of the appendages, ovaritis, infectious or otherwise, or exercise an influence on a pre-existing tumour of the uterus or ovary.

Prolapse of the genital organs can undoubtedly come about under the influence of a physical and psychical injury (violent exertion, acute uterine version, prolapse of the ovary or Fallopian tube, general prolapse, utero-ovarian troubles, due to a shock, amenorrhoea, haemorrhage, pains). According to Au-vray, however, the absolute relation of cause and effect between the injury and the disorders found is exceptional.

Hygiene

Under the present social conditions, the acceptance of paid work is an imperative economic necessity for a great number of women, and whether it be a desirable state of affairs or not it is one which in all countries is in course of rapid development. Consequently, there exists a strong obligation to provide adequate means of protecting as far as possible the physical well-being of women workers.

Social hygiene ought to pursue the aim of diminishing, if not suppressing, the causes injurious to health. Preventive measures in the case of women and mothers in employment are very numerous and may be either voluntarily accepted or statutorily imposed. There is no branch perhaps in which preventive medicine can do more good.

Medical supervision from the time the girl enters school, the granting of a certificate of fitness on commencing employment subsequent to medical examination, periodic medical examination during adolescence while at work, are the needful steps to ensure the normal march in development of the young girl and to enable her to choose the work most fitted to her physical and intellectual qualities.

The question of occupational orientation in the case of a woman is certainly not too simple. Account must be taken not only of her greater susceptibility to poisons, but also of the great emotional side of her life, her impressionability and quickness of reaction.

Abolition of night work and diminution of the working hours have certainly played an important role in bringing about the almost total disappearance of chloro-anaemia, which was so frequent until only a few years ago among working women.

While acute or chronic diseases do not exercise great influence on the choice of a profession, gynaecological diseases according to their nature play a different role. Hence exclusion from heavy work in the case of ptosis or uterine prolapse; similarly, too, in cases following inflammation of the appendages, which sets up pains hindering all activity and sometimes necessitating operation, etc. Venereal diseases exclude those suffering from them from a very important set of occupations, notably children's nurses, servants, children's governesses, sick nursing, handling of alimentary products in the factory or at home, etc.

Generally constitution and temperament impose conditions in the choice of a profession. This is why Lehmann is able to state definitely: "All advice as to choice of a profession is held up by the fact that for weaklings there is no profession they can carry on without harm to themselves, and injurious trades require the best human material, which in the end is only destroyed by them.".

Hence the prime importance now admitted of a good medical unity in the factory: examination at the commencement of work and periodically afterwards. The surgeon should pay particular attention to troubles of the generative system enabling him to detect pregnancy at an early stage and to give all the information that might be useful then. He should assure himself that the woman is not suffering from her work and that the work is placed in the hands of those most

1 P. Salé (1922), in his book Gynécologie et Accidents du Travail, has analysed the role of emotion and nervous influences.
competent to do it. To carry out effectively this double task, the surgeon must possess the confidence of the management and the workpeople, as well as a profound knowledge of the technique of the processes carried on in the establishment.

It can be readily understood for what reasons this post can be best filled by a woman doctor already possessed of some practical experience. The medical supervision should be organised in such a way as to afford proper treatment for accidents, dental defects, eye affections, etc. (see article "Medical Inspection"). In the article "Social Welfare" are described all the activities that are desirable for the protection of the woman worker. Further on (under Legislation) the dangerous, injurious and unhealthy industries which are wholly or partially prohibited by law for women are mentioned. It should not be forgotten that these restraints, necessary to safeguard the health of the woman and maintain the standard of the race, raise considerable economic or technical difficulties on which there is not space to dilate here.

But every difficulty must be overcome where protection of the expectant mother is in question.

It has been seen that sufficient rest, peace of mind, sufficient food, and a healthy mode of living constitute the fundamental basis for ensuring the normal progress of pregnancy and physical development of the offspring.

On the other hand, it is advantageous, both for the employer and employee, that the latter should work as long as possible without risk to herself or child.

Antenatal consultation, therefore, should be organised so as to afford adequate advice and medical supervision through the whole period of pregnancy. The sanitary service should be in close touch with the management so as to secure such change of work as may be desirable. The expectant mother should not be given work involving more than moderate effort in its character and duration. The view being accepted that every process injurious to the health of woman is still more so for the expectant working woman, should lead the doctor to ask for her transference from the third month at least of pregnancy to a department free from risk of poisoning. Similarly the expectant mother should not engage in any occupation exposing her to accident, fatigue, or vibration, etc. The half-day system, with a maximum of six hours, should be applied for preference. Naturally there should be no night work.

Every woman in whom pregnancy appears to be developing abnormally should not be allowed to continue at work, and should only be allowed to return to work on production of a medical certificate.

Any change in employment, reduction or cessation of occupational activity should not involve diminution of salary for the expectant mother.

So far as the woman with an infant is concerned, the necessary welfare arrangements envisage particularly facilities for nursing her child (see article "Social Welfare"): these take the form of nurseries, crèches, nursing rooms, rest pauses for working women to allow of nursing, distribution of milk, etc.

**LEGISLATION**

Reference should be made to the article "Children" for legislative enactments as regards girls. Generally speaking, legislation relating to women's work is less strict in the case of adult women, because the majority of countries have enacted laws to protect females up to the age of eighteen or twenty-one years of age, as well naturally as during the time of pregnancy and childbirth.

It is necessary, however, to extend this protection, especially where questions of fatiguing, unhealthy or dangerous work are involved. Thus, for example, women are excluded in some countries from dangerous work (explosives, etc.) or very fatiguing work (mines, etc.); loading and unloading of ships controlled by cranes; work as mechanics or chauffeurs; oiling and cleaning machinery in motion; attending to belts; work with circular saws and other dangerous tools; metal casting; glass blowing; carrying of burning materials; sale of distilled alcoholic drinks, etc. The expectant mother should never be allowed to lift heavy weights.

Hours of work of women, weekly rest period, prohibition or limitation of night work and a period of absence from work before and after childbirth are statutorily regulated.

These matters of statutory observance have also been dealt with internationally: the International Conference at Berne in 1908; as regards night work; the International Labour Conference, Washington, 1919, and later ones on other questions.

The following Conventions were ratified by the States named or approved by the national competent authority up to 1 September 1928:

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While factory work is not good for the expectant mother, it is not right to exaggerate and pretend that it is one of the main causes of the lowering of the birth-rate. Protection of the female worker has been the subject of a full discussion in the Academy of Medicine of Paris (1915-1917) — a discussion which gave expression to certain resolutions (cf. Frois: *La santé et le travail des femmes pendant la guerre*, p. 125).
...at any rate twenty-one (women employed at the mines in Belgium, Spain, Italy, or, at any rate, their admission is only authorised under certain conditions laid down in regulations). Certain industries or processes attended with less risk are permitted in the case of girls aged from sixteen to eighteen years, as well as women, provided that the employer adopts the proper measures for removing the danger in question (by fans) such as dusts, fumes, gases, etc.

Generally speaking, it may be said that women and young persons of less than eighteen years of age cannot be employed in injurious or unhealthy establishments where they would be exposed to manipulations or emanations prejudicial to health, except under the special conditions laid down in regulations for each one of the industrial processes.

 Mention should be made here of the method followed by the Netherlands Factory Act, authorising only the employment of women and young persons in factories and workshops where a required cubic space per person, a minimum standard of lighting, sufficient ventilation, and a temperature not defined, are provided in the case of girls aged from fourteen to sixteen years of age and of girls and women if the work of lifting, dragging, pushing, lifting and for expectant mothers: all carrying and removing a heavy object, demands too great effort or presents danger to health.

Other countries have laid down in detail the limits which must not be exceeded in pushing, dragging, etc., according to the age and sex of the workers. Thus, for example, these weights must not exceed for:

Children aged 12 to 15 years, 15 kg.; girls, 5 kg. (Italy).
Under 14 years, 10 kg.; girls, 5 kg. (France).
Children of both sexes, 5 kg. (Greece).
From 14 to 15 years: boys, 15 kg.; girls, 8 kg. (France).

...
Under 16 years: boys, 10 kg. (Argentina, Spain); girls, 5 kg. (Argentina); 20-25 kg. in the textile industries (Great Britain).

From 15 to 17 years: boys, 25 kg.; girls, 15 kg. (Italy).

From 16 to 17 years: boys, 20 kg.; girls, 10 kg. (France).

From 16 to 18 years: boys, 25 to 32.5 kg. (Great Britain, textile industries).

From 16 to 20 years: women, 10 kg. (Argentina).

From 17 years and over: women, 20 kg. (Italy).

Less than 18 years: women, 20-25 kg. (in the textile industry, Great Britain), 10 kg. (Greece), 13 kg. (Victoria).

From 18 years and over: women, 30 kg. (France); men, 60-75 kg.; women, 25-35 kg. (textile industry, Great Britain).

Women: maximum, 36 kg. (California), 11 kg. (Ohio, New York), 16 kg. (Russia).

The maximum loads which may be pushed or dragged, including the vehicle, are the following for different age groups and different types:

(a) Trolleys, Wagons, or Trucks, with 3 or 4 Wheels

Less than 14 years: boys, 35 kg. (France), 30 kg. (Spain); girls, 20 kg. (Spain).

Less than 15 years: boys, 120 kg.; girls, 40 kg. (Italy).

From 14 to 16 years: boys, 50 kg.; girls, 40 kg. (Spain).

Less than 16 years: boys, 35 kg. (Argentina); girls, 35 kg. (France).

From 14 to 17 years: boys, 60 kg. (France).

From 15 to 17 years: boys, 200 kg.; girls, 120 kg. (Italy).

From 16 years and over: girls, 60 kg. (France).

Less than 18 years: girls, 35 kg. (Argentina), 50 kg. (Greece).

From 17 years and over: women, 160 kg. (Italy).

From 18 to 20 years: girls, 50 kg. (Argentina).

(b) Hand Barrows

From 14 to 16 years: boys, 40 kg. (Argentina, Spain).

From 14 to 17 years: boys, 40 kg. (France).

From 18 years and over: girls, 40 kg. (France).

(c) Trolleys with Handles and 2 Wheels

From 14 to 17 years: boys, 130 kg.

From 18 years and over: 130 kg. (France).

(d) Wagons or Trucks on Iron Rails

Less than 14 years: boys, 300 kg. (France), 200 kg. (Spain); girls, 150 kg. (Spain).

Less than 15 years: boys, 300 kg.; girls, 100 kg. (Italy).

From 14 to 17 years: boys, 500 kg. (France).

From 15 to 17 years: boys, 500 kg.; girls, 300 kg. (Italy).

From 14 to 16 years: boys, 300 kg.; girls, 250 kg. (Spain).

Less than 16 years: boys, 300 kg. (Argentina); girls, 150 kg. (Argentina, France).

From 16 to 17 years: girls, 300 kg. (France).

From 17 years and over: women, 400 kg. (Italy).

Under 18 years: women, 300 kg. (Greece).

From 18 years and over: women, 600 kg. (France).

(e) Foot Pedalling Tricycles

From 14 to 15 years: boys, 50 kg. (France).

From 14 to 16 years: 75 kg. (Spain).

From 16 years and over: girls, 75 kg. (France).

Italian regulations forbid the carrying of weights by women and children for more than four hours in the working day; control and dragging of trolleys by women and young persons of less than eighteen years of age; carrying of loads by means of wheelbarrows or two-wheeled wagons in the case of children of less than fifteen years, if the work has to be carried on under special conditions of fatigue or danger; all carrying of loads by expectant mothers in the sixth month of pregnancy and after.

The work of oiling, cleaning, visiting, and repair of machinery in motion is forbidden to women, as well as all work in front of machinery which is not properly safeguarded (prevention of accidents).

French legislation (Decree of 21 June 1913) prohibits the employment of boys of fourteen and girls under sixteen years of age on outside scaffolding of warehouses and shops. Boys from fourteen to eighteen years of age and girls from sixteen to eighteen can only be employed for six hours a day, in shifts of two hours or more, with an interval of one hour at least. Children under eighteen years and women are excluded absolutely from this work after 6 o'clock at night and when the temperature is below 0° C. In the latter case the employers must place means of heating, arranged inside the building, at the service of the workpeople.

Young persons of less than eighteen years and women are not allowed to take part in the preparation and sale of printed matter — placards, drawings, engravings, etc. — which are of a kind to corrupt their morals.
<table>
<thead>
<tr>
<th>Country</th>
<th>Field of application of the law</th>
<th>Periods of rest (in week)</th>
<th>If supplementary holiday is granted or not</th>
<th>Rest pauses granted or not for nursing</th>
<th>Crèche if necessary</th>
<th>Compensation in money</th>
<th>Medical attendance</th>
<th>Compensation in money over and above medical attendance</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>I. C.</td>
<td>6</td>
<td>6</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Public funds or insurance</td>
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<td>6</td>
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<td>Yes</td>
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<td>No</td>
<td>No</td>
<td>No</td>
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<td>No</td>
<td>Insurance</td>
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<td>No</td>
<td>Insurance</td>
</tr>
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<td>Austria</td>
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<td>No</td>
<td>No</td>
<td>Insurance</td>
</tr>
<tr>
<td>Belgium</td>
<td>I. C.</td>
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<td>4</td>
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<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Insurance</td>
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<tr>
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<td>12 altogether</td>
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1. = Industry;  C. = Commerce. The countries omitted on the above list are those of which no data are available.
It would be a good thing for women, and particularly for young persons, to be subjected to a careful examination as to their fitness for the work they are called on to do, and also to a periodic medical examination, especially when there is any likelihood that the work might be injurious to health.

Protection is especially called for in the case of the mother (childbirth, nursing). At the present time legislation has laid down the measures set out in the table on page 1260.

In many countries voluntary help comes in to aid the Government in the carrying on of statutory requirements, e.g., the "Opera nazionale per la protezione dell' infanzia e della maternità", which has just been formed in Italy (1926), etc.

Without entering here into the controversial point as to equality between men and women in regard to work, there can be no doubt that, up to the present, all legislation for the benefit of women and children has also benefited men as well. These measures have been of really great value in improving the hygienic conditions of workrooms and preventing fatigue.

The Women's Bureau of the Department of Labour in the United States is about to adopt (1928) a certain number of "standard" conditions to govern women's work. These conditions, drawn up during the war by a committee composed of representatives of employers, workpeople, and the Government, yielded after the war very satisfactory results.

The conditions asked for were:

1. Equal wages for equal work, without distinction of sex or race.
2. Eight-hour day, half-holiday on Saturday; one rest day in seven.
3. Thirty minutes at least for meals.
4. Ten minutes' rest interval in the middle of each half-day, without prolonging the working day.
5. No work between midnight and 6 o'clock in the morning.
6. Cleanliness of the workrooms; special attention to be given to the floors to prevent slipping.
7. Sufficient lighting without flickering.
8. Adequate ventilation; arrangements to be made against heat, humidity, dust, smoke, and fumes.
9. Guarding of machinery; measures to be taken to prevent fires and any other danger.
10. A chair to be provided for every woman, made to suit the position assumed at work and suited both for the worker and the work. Avoidance of always adopting the same position whether seated or standing.
11. Drinking water to be easily accessible with drinking cups for each worker, or hygienic fountain.
12. Suitable sanitary accommodation readily accessible; hot and cold water, soap and towels for each person.
13. Suitable washing accommodation (1 to 15 women).
15. Mess-rooms, separate for each sex, with arrangements for warming food.
16. No prohibition of women's employment in any industry whatsoever, unless it is shown to be more dangerous for women than for men.
17. No home work.

The Women's Bureau recommends also a department in each factory charged with the duty of choosing, placing, transferring and dismissal of workpeople, and especially of seeing that conditions of work are as good as they can be made. A trained woman should be deputed to deal with questions affecting the workpeople.

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WOOLLEN MANUFACTURE — 1862 —


For the numerous works on this subject, cf. the Bibliography of Industrial Hygiene, published quarterly by the INTERNATIONAL LABOUR OFFICE.

The illustrations are reproduced by courtesy of the Deutsche Textilarbeiter Verband.

Dr. (Mme.) Fuss
(Geneva).

Woolen Manufacture


IMPORTANCE OF THE WOOLEN INDUSTRY

It is fairly difficult to estimate in exact figures the production of wool for the entire world, but to do so is not of great importance from our point of view. The number of sheep on the earth's surface is estimated at about 700 millions. An idea of the industrial importance of wool in industry, however, may be derived from the following rather incomplete table, which shows the production of wool in thousands of metric tons for 1927:

<table>
<thead>
<tr>
<th>Country</th>
<th>Wool Production (thousand metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>148.8</td>
</tr>
<tr>
<td>Argentina</td>
<td>146.1</td>
</tr>
<tr>
<td>South Africa</td>
<td>108.0</td>
</tr>
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<td>Spain</td>
<td>47.6</td>
</tr>
<tr>
<td>U.S. S.R.</td>
<td>143.8</td>
</tr>
<tr>
<td>Great Britain</td>
<td>53.8</td>
</tr>
<tr>
<td>Australia and Tasmania</td>
<td>538.0</td>
</tr>
<tr>
<td>Uruguay</td>
<td>58.5</td>
</tr>
<tr>
<td>India</td>
<td>94.9</td>
</tr>
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</tr>
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<td>Italy</td>
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<tr>
<td>France</td>
<td>21.5</td>
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</table>

The countries marked 1 are engaged especially in the production and exportation of wool.

These statistics do not take account of importation of wool, which in industrial countries is very important. Thus, for example, France is equipped to deal with three million cwts. of wool, in which the native production appears as a very small figure. A further remark that should be made is that some countries enter in their statistics of wool certain fibres derived from animals other than the sheep, as, for example, Great Britain and the United States of America, which include under "wool" goat hair, mohair, llama, alpaca, and camel hair.

Nevertheless, the table cited suffices to show the distinction between producing and manufacturing countries.

PROPERTIES OF THE FIBRE

The length, fineness and colour of the wool are very variable. The wool is classified in two groups — short and long. Among the former are those measuring from 25-30 mm., and among the latter some that may reach 250-300 mm. Anatomically, the fibres are derived from animals other than the sheep, as, for example, Great Britain and the United States of America, which include under "wool" goat hair, mohair, llama, alpaca, and camel hair.

The fineness of the fibre is an essential quality, varying from one-fifteenth to one-sixty-fifth of a millimetre. Account must be taken of its suppleness, elasticity, strength, and lustre. The colour may be amber, brown or black; white wool is preferred.

Details as to the different qualities are not of importance here; these depend on the species of sheep, method of nurture, or the climate. The race producing the most famous wool is the merino sheep, originating in Spain and spreading hence by crossing with indigenous races in the producing countries or being further improved by selection.

Power to be able to distinguish the qualities of the wool is useful, in order to recognize the uses for which they may be suitable and the final object of their utilization; fine cloth, coarse cloth, carpet manufacture, hosiery, blankets, felt, mattresses, etc. A word, too, should be devoted to the hygroscopic properties of this fibre, in order to understand why it can only be properly manipulated in a dry atmosphere somewhat different from that most suitable for man from a health point of view.

Temperature and humidity are known to have a distinct influence on all fibres of whatever kind, and they cannot be easily worked beyond a certain optimum temperature and humidity. From this point of view, wool is the most sensitive of the textiles for the following reasons. Cotton fibres are manipulated in work-rooms both warmed and humidified, for by heat the fibres become more elastic and humidity gives them greater resisting power. A similar result is not required in the case of wool, the fibre of which is longer than that of cotton and more resistant, as its diameter is greater. Heat, it is true, gives it suppleness, but humidity, instead of strengthening, tends to weaken it, so that, on the contrary, it acquires on absorption of water quite a special elasticity. But this absorption takes place without difficulty, because of the hygroscopic properties of the wool.

These data are indeed in general exact, although the capacity for absorption by wools varies with their origin and other physical qualities.

Account must be had, too, of electrical phenomena. When wool is rubbed against a piece of metal, the two bodies become charged with electricity, the intensity of which increases with their dryness. It follows that there is an attraction between them and a repulsion between the fibres.
This is noticeable especially in the work of combing, where it is necessary that the fibres glide readily over the metal parts and be not retained there. Nothing like this takes place in a humid atmosphere. The presence of steam in the air renders this a conductor and hinders accumulation of the electricity generated by friction on the surface of the fibres.

**INDUSTRIAL PROCESSES**

The woollen industry comprises two main divisions, that of combed and that of carded wool.

**Combed Wool**

Combing, which is done for light and fine articles for which there is no necessity for fulling is done in two kinds of establishments, generally distinct: combing and spinning.

Combing comprises five successive operations, viz. sorting, desuinting or steeping, washing, carding, and combing proper.

**Sorting.** — The wool arrives loose or in fleeces. The former applies to the inferior qualities of wool, or to wool that has been subjected to preliminary washing in the country of origin. Fleece wool has to be sorted, that is, to be opened over screens in order to separate the fibres which are of different qualities according to the part of the body of the animal from which they are taken. Thus the wool taken from the back of the neck is very short. The wool from the back or upper part of the neck is spoken of as prime firsts; seconds come from the sides; thirds from the belly, while brittle is that which is taken from the haunches of the animal. "Fallen fleeces" is the name given to wool when it is taken from an animal after its death.

Sorting is done by workmen who have undergone a fairly long apprenticeship. The different qualities of wool separated one from the other are placed in separate baskets; coloured wools are placed apart.

Sorters are liable to breathe the dust which is given off by raw wool. Some wools are very much dustier than others. They run the risk of inhaling the spores of anthrax, particularly of wool coming from countries where no veterinary supervision of the flocks exists (see the article “Disinfection of Wool” under Dangers).

When dusty and so-called dangerous wools are handled (because they come from districts where anthrax is endemic) sorting should be done over screens or hurdles with locally applied downward exhaust ventilation, which must not be too powerful for two reasons: firstly in order that the fibres may not be carried away, and, secondly, because a strong draught diminishes the sense of touch and appreciation of the qualities of the fibre in the sorter which is based solely on the sense of touch (see also the article “Rags”).

After drawing, the wool is sometimes classed according to quality. Certain wools are passed to the willying machine (those containing a high proportion of dust and straw). Willying of dirty, dusty wool or wool contaminated with vegetal debris is done in a machine provided with powerful exhaust ventilation. The impurities are intercepted in a chamber and forced back in such a way as to be separated from the air, which passes sufficiently purified into the atmosphere.

**Desuinting or steeping.** — Desuinting has for its object the removal of the grease from the wool (French: Suin de la laine; German: Wollfett; Spanish: Grasa de lana; Italian: Grasso di lana).

The mixture of secretion from the sweat and sebaceous glands of the skin of the sheep forms a yellowish viscus mass, which contains mud, debris of straw, and other impurities, which constitute the suint on wool. Apart from the impurities mechanically adherent, it contains matter coming from the sweat glands rich in potash salts soluble in water, and matter insoluble in water — the grease coming from the sebaceous glands, which can be extracted by volatile solvents.

The suint is a complex mixture of neutral others, free acids and alcohols. There are found, in the form of salts, the following acids: formic, acetic, propionic, valeric, stearic, lactic, oxalic, succinic, malic, uric, etc., leucin, urea, chlorides, phosphates, silicates of potash, soda, etc. Its quantitative composition varies within large limits. From the chemical point of view, it is a wax saponifiable with difficulty, soluble in the majority of organic solvents, and making an emulsion with water.

The quantity of suint contained in wool is extremely variable; the finer the wool the more greasy it is. As much as 75 per cent. is found in very fine wools. The suint gives a yellowish brown dirty colour to these latter, and a rather light yellow colour to the other varieties.

Desuinting is done by treating the wool in a warm alkaline bath, followed
immediately by washing to remove the earthy matters which might further soil the wool. After having extracted the potash from the suint, the fatty matters are extracted. These are used for making ordinary lubricants, destined for the hide and skin industry, and especially for lanoline, olein, and stearin.

The suint is sometimes treated on woolcombing premises, but generally in special factories. The treatment gives rise to nauseating smells, which are unpleasant for the neighbourhood unless they are discharged into the furnace fire to be burnt, or discharged at a height into the atmosphere.

Extraction of fatty matters is done in presses, and by treating the resultant cake by means of volatile solvents: carbon bisulphide, benzene, petrol, tetrachloride of carbon, etc. (see “Fatty Substances (Manufacture of)”). Desuinting by means of solvents is becoming more and more usual. It is possible to recover the product. When carbon bisulphide is used washing is carried out in turbines hermetically closed; if petrol or gasoline be used, it is done in a series of closed vessels. There follows often treatment by water and a weak alkali or soap by means of a washing plant, washing by solvents being insufficient.

Workers at home, it should be recalled, are said to recover the suint by means of decomposing urine.

Washing. — Washing is effected mechanically in a series of four or five metal tanks, containing soapy water heated to 40 or 50° C. The wool is emptied into the first tank, and gradually worked from one tank to another by mechanically moved foris or rakes. In passing from one tank to another it passes between rollers, which squeeze out the liquid. On leaving the last tank it passes into a hot air drier and is carried to the warehouse, where it is baled or sent to be combed, if the process is carried on in an independent wool-washing establishment supplying another factory.

This is the arrangement in the British Government wool disinfecting station, near the docks at Liverpool, to secure disinfection of wool coming from countries from which anthrax infected wool may be imported (see also following article “Wool (Dis-infection)”).

It would be desirable to demand such disinfection for all imported wool were it not for the fact that it is indispensable to sort the fleece wool; and to be effective disinfection must be done on the raw material before sorting. Sorters are the first to suffer from anthrax. On the other hand, true sorting becomes impossible after washing, at any rate for the kinds most used for combing.

Carding. — Although combed wool is in question, the fibres must be passed through a carding machine. This operation has for its object the removal of the vegetable debris and burrs which have not been removed by washing, and to make the fibres lie parallel to one another, so as to form as regular a sliver as possible throughout its length. Removal of this vegetable matter is best done when wool is dry; carding requires, on the other hand, the wool to be moist. These two contradictory necessities are secured by heating that part of the cards where the removal is done in such a way as to make the wool lose momentarily its moisture, and by maintaining in the workroom a sufficiently relative humidity to allow of the fibres rapidly reabsorbing the moisture which it is necessary for them to possess to avoid ill-effects from the development of electricity. For this kind of work there is no disadvantage in keeping a temperature below 22° C. Humidity should reach 75-80 per cent.

Apropos of the temperature and humidity necessary to ensure good carding, a general remark applying to all workrooms should be made. While it is easy enough to keep up the required relative humidity, it is much more difficult to secure the same uniformity in regard to temperature, which cannot always be controlled (external influences, changes due to conduction, etc.). Moreover if the temperature varies — a fact which cannot be avoided — the relative humidity follows inversely pari passu.

In order to avoid the inconveniences resulting from a fall in temperature, and, above all, of diminution in the degree of saturation of the air, there is a tendency in practice to exceed the standards that are looked upon as optima — a result not advantageous from the health point of view (see the article “Air — Hot and Humid Atmospheres”). On the other hand, any draught is considered to lead to a drying of the atmosphere injurious to the work which technical experts think can only be carried on properly in a stagnant atmosphere — a circumstance which again increases the warmth and humidity of the air to an unpleasant degree.

In Champagne, the wool worked in the cards is formed of noils of combed
wool and waste wool that has not been combed. For a long time the cards have been provided with an unventilated method of dust extraction, of which the Lelarge system is said to give excellent results both in practice and from a health point of view.

**Combing.** — On leaving the carding machine the sliver formed by the worsted fibres undergoes a preliminary preparation for combing by passing between rollers of a comparative rapidity set to work in such a way that the number of fibres placed side by side diminishes progressively so as to form a sliver both finer and less charged with fibres. The sliver then goes into a machine which divides it into sections, combs it, removes all the impurities and inequalities without leaving the smallest bit or the smallest fibre not of the desired length, and then reconstitutes a continuous sliver. All this is done automatically. Without going into unnecessary details it will suffice to say that there are two kinds of combs: one worked cold and the other hot.

Combing is spoken of as "greasy" when done before smoothing, that is, before removal of the small quantity of oil added to the wool after the drying following washing, to render it less friable and more supple. Combing is spoken of as "fine" (French: maigre) when it takes place after smoothing.

As in the card room a temperature of 22° to 25° C. and a relative humidity of from 75 to 80 per cent. is considered necessary. In practice not infrequently the temperature rises to 30° C., sometimes even 40° C. with a relative humidity of from 70 to 75 per cent. In the rooms where the drawing, combing and smoothing, etc., frames are found, as well as the many steam pipes (often without insulating covers).

**Back washing.** — Back washing is the process taking place either before or after combing, and has for its object the removal of the oil impast on the oiling process.

The wool is placed in tanks containing water at 50° to 55° C.; from there it passes between a series of steam-heated cylinders to remove the excess of humidity.

To draw off the steam and to prevent loss of heat from the cylinders their upper part is surrounded by a hood of special design in which a current of air circulates.

**Finishing after combing.** — After leaving the combs the "tops" are made to pass through various drawing machines to make them uniform; these are named according to the use for which they are designed: Gilloch intersecting à pots tournants (Gilloch intersecting mit Drehloffen); étrage à pots tournants (Strecke mit Drehloffen); étrage en gros (Grobstrecke); étrage frothoirs (Frottirstrecke); bobinoir intermédiaire (Mittelfrotteur); bobinoir finisseur (Feinfrotteur), etc.

In the course of these drawings the original sliver becomes reduced in thickness, the fibres composing it lie more and more the one against the other, constituting a kind of mesh which must permit of lengthening in spinning and of torsion. This indispensable process in the manufacture of wool is called preparing. It is even spoken of as the soul of spinning.

The wool fibres naturally during all these processes, stretch, dry, and become electrified. A fair temperature must be maintained (22° to 25° C.) and a certain humidity of the air (75 to 80 per cent.).

**Spinning.** — After leaving the preparing machines the sliver has become a mesh which is converted into a thread by spinning.

This change is effected by means of a machine which works intermittently, named "self acting" or a dividing machine or by means of machines spoken of as "continuous spinning frames": the first yielding a very fine thread, the second having a larger yield proportional to the cost of manufacture. At self-acting mules the workers are men or young persons, at spinning frames women or girls.

The temperature and state of humidity in the spinning room depends on the kind of thread spun, the material being worked, and the kind of machine used.

With the spinning frames producing threads of not more than 45 counts for warp and 40 counts for weft, 75 to 80 per cent. of humidity and a temperature of 22° to 25° C., as in the preparing, is required.

With mules capable of producing threads of counts up to 120 (120,000 metres to the kilo) the temperature and humidity required is as follows:

<table>
<thead>
<tr>
<th>Humidity</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent.</td>
<td>°C.</td>
</tr>
<tr>
<td>From No. 10 to No. 35</td>
<td>80</td>
</tr>
<tr>
<td>...</td>
<td>35</td>
</tr>
<tr>
<td>...</td>
<td>60</td>
</tr>
</tbody>
</table>

For surface used the spinning frames give off more heat than do mules. More powerful methods of humidification must therefore be in-
ststituted in summer for them than for mule spinning.

Carded Wool

All that has been said applies to combed wool; the work of carded wool is rather different, although not dissimilar.

Both fine and coarse materials, the staple of which is deficient in length and curl, are used for carded wool. Waste from combing is added under the name of noils and even waste from shoddy and sometimes cotton (see also the article "Shoddy"). The processes used are as economical as possible because of the inferior quality of the wool.

They are less numerous than in combing. All that is wanted is to obtain a thread which is resistant and regular — this last condition being essential. The processes through which the material passes are: blending, oiling, carding, and spinning.

Blending. — The object of this is to blend the raw materials so that they correspond with the quality and price at which the thread to be manufactured is sold.

Into the blend enters a proportion more or less high of fresh wool, so called because hitherto it has not been worked up. Although blending is an essential process, further description of it need not be given except to say that it frequently ends by being willeyed or passed through machines called "devils" or "willeys".

Oiling. — This has for its object to counteract the defects in the fibres specially chosen for carding because of their lack of length or because the texture of the fibres permits an easier slipping action than with carded wool. The process consists in sprinkling the wool with a mixture of oil and soap of which the proportions vary according as to whether the thread to be prepared is intended for warp or weft.

Carding. — After oiling the wool is willeyed to equalise the distribution of grease and is then despatched to the card or rather to an assortment of three or four cards, each of which has a special rôle.

The first card (scribbler) commences the unravelling of the fibres; the second or third and fourth follow (if there are four cards) and are called intermediates. The last card (condenser) is provided with an apparatus which divides the wool upon the doffer into several strips passing between rubbers which are intended to roll them and change them into sliver.

Spinning. — On leaving the cards the sliver passes on to mules somewhat similar to those referred to before to be converted into spun thread.

According to the kind of thread required this operation is done once or twice; if twice the process is done successfully on two mules. There is coarse and fine spinning. Spinning of carded wool is intended for the manufacture of closely woven goods.

If it is desired to spin coloured thread the wool is generally dyed en masse before oiling. Blends can then be made with different shades so as to arrive at special shades or particular effects (see article "Dyeing").

Oiling having for its object to supply the fibres with greasy matter to give them the suppleness they lack, the conditions for its treatment in regard to temperature and humidity are not the same as for combing. Nevertheless precisely on account of the presence of a greasy material which must not congeal but remain smooth and slippery the temperature must be above the average. Experience shows 22° to 24° C. is about right in the case of carded wool while the humidity should not be less than 60 per cent. for carding and 70 per cent. for spinning.

Spinning of carded wool — this being inferior in quality to combed wool — has in France, at any rate, produced the only cases of anthrax which have been verified from wool.

English Methods

In Bradford the processes, if not the equipment, differ a little from that which has been described. In combing, the temperature and humidity do not need to be so high as in France. This is due to the fact that in Great Britain even the long and fine wool is more abundantly oiled. Thus when question is raised as to the injurious action of the warm and moist air in wool spinning, the English have always had in mind spinning carried on by the "French process".

Gassing the Threads of Wool

However carefully mule spinning or spinning frames are run, the extremities of the filaments of the thread project beyond the compact cylindrical portion of the thread. To make this look nicer the extremities are burnt by making

1 This method is followed in about a dozen establishments in the region of Bradford.
the thread pass at great speed through a gas jet. During this operation — known as "gassing" — matter which is deposited near the jets, carbonic acid gas, smells and a little carbon monoxide are given off. The jets are supplied with coal gas, water gas either alone or mixed with coal gas or again with a mixture of air. Only a portion of the woolen threads undergo gassing.

A visit to a gassing room is always unpleasant and particularly so in the case of wool because of the albuminoid matter burnt. Further the heat is considerable and there is much fine carbon dust.

Researches by Thorpe, at the request of the Home Office in London, showed that for every cubic metre of gas burnt from 1.24 litres to 2.23 litres of carbon monoxide was given off depending on the kind of burner used and the kind of gas.

Such ventilation, therefore, must be assured as will exert a downward exhaust below each burner through an opening of small diameter so that the air aspirated comes from above, sweeping across, so to speak, the worker's breathing level without affecting the flame jets. Mr. Smith saw this system at work near Bradford in 1903 and expressed satisfaction with it. Use of burners with the flame reversed avoids certain inconveniences.

More recently gassing of the threads has been tried using platinum wires heated by electric current instead of gas jets. This method, even in the case of cotton, which gives rise to less waste, has been discontinued.

The bleaching of the wool, which has for its object to obtain unshrinkable material as slightly sensitive as possible to the phenomena of felting when washed with hot soapy solutions and to enable the wool to fix successfully certain imprinted dyes, is done generally with chloride of lime by a single or two bath process (hydrochloric acid bath and chloride bath). Recently the proposal has been made to fix simply dry chlorine or liquid chlorine on the dry wool while it is being stored for the purpose of dying. A fan removes the excess of chlorine.

DANGERS

The danger varies with the different industrial processes. The sorters run the risk of dust and anthrax. The woolwashers, on the other hand, are exposed to extremes of temperature, humidity, caustic and irritating action of alkaline solutions and acute and chronic intoxication from the volatile solvents.

Carding throws into the air fragments of wool fibres which remain suspended a long time and may set up lesions of the mucous membranes, especially of the respiratory tract. Spinning does not create dust because of the moisture present in the atmosphere.

As the effect of warm and moist air is the subject of a special article (see "Air — Hot and Humid Atmospheres"), reference to it here would be out of place. Nevertheless it must be admitted that a noticeably unpleasant atmosphere exists in fine wool spinning rooms. The temperature below which it would not be practicable, on technical grounds, to fall is 25° C. and a relative humidity of 90 per cent. for preference. In summer, however, difficulty is experienced in not exceeding this, with consequential necessity of maintaining the saturation of the air. Soon after the spinning frames start working a portion of the mechanical force destroyed becomes transformed into heat. At midnight the effect of the external temperature is felt still further and frequently the thermometer may reach 30° and even 35° C. And the high temperature is further aggravated by the fact that movement of the air is avoided, especially in the mule-spinning out of order to prevent the thread becoming entangled.

During recent years the barium chloride method of treating wool for mattresses has been introduced. Wool thus treated is said to have a better appearance, to be whiter, to lose part of the impurities which the ordinary method fails to remove, to be more resistant to moths, to disinfection, etc. The wool is treated with a solution of chloride at 10-14° B. and dried. Although chloride is fairly toxic, no case of poisoning of industrial origin has been known to occur. Nevertheless, it is advisable to ensure for workers employing this method certain aids to personal cleanliness (wash basins, douches; mouth rinses for carders).

PATHOLOGY

This varies with the different processes. Thus, for example, wool-sorters run the risk of dust inhalation and of anthrax infection — by no means negligible (see the article "Wool (Disinfection)"). Forms of

It has been noted at times to have attained about 60° C. during combing.
mycosis are reported (from Aspergillus niger or flavescens) localised in the external auditory meatus, middle-ear inflammation; tonsillitis, conjunctivitis, etc.

Among woolwashers, there occur cases of poisoning (dermatitis principally) caused by the arsenic used to preserve the fleeces; intolerable discomfort and even ulceration of the skin (when not protected); bronchial irritation from use of a soap prepared with a silicate containing microscopical spicules of fossil animalculae (Gilman Thompson, U.S.A.). The dermatitis described is closely connected with the use of alkalis. Poisoning from volatile solvents is possible but rare.

Dermatitis has frequently been set up by the use of wool waste mixed with silicates to form non-conducting material for insulating boilers and pipes. This occurs, too, in workers engaged in desuing wool in dye-works, etc. In this department cases of poisoning by lead (from chromates) anilin, arsenic colours, vapours, acids, etc., may occur.

The oil causes among spinners, especially in young persons and apprentices, an acne on the unprotected parts of the skin. Dryness, high temperature, and lack of cleanliness favour its development. The acne is situated mostly on the arms. (For twistcrs' cramp, see the article "Cotton").

The effect of the conditions described cannot readily be shown in figures. Comparison can be made between districts where no woollen industry exists and those where it does. Thus, for example, British comparative mortality statistics show that wool operators have a lower death rate from respiratory diseases than do all occupied and retired males. In France, in the southern portion of the Département du Nord, two very distinct and different industrial groups are found, namely, that of Fourmies (wool) and that of Maubeuge (iron). If comparison is made of the proportion of workmen rejected per year or, what is more satisfactory, for a group of years (from 1904 to 1908), it works out that 31.7 per cent. of spinners are unfit for military service and only 12.9 per cent. workers in other trades.

The same relation is found at Sains-du-Nord: wool spinners 30.7 per cent.; other professions 12.6 per cent.

The same facts emerge if another textile district in the Département du Nord, that of Roubaix-Tourcoing, is selected, although not quite so saliently, because along with the wool industry the cotton industry flourishes, and it is not always possible to know to which of these two industries the rejected conscripts belong as both are entered as spinners or piecers, or fly-frame helpers without any indication as to whether they belong to the woollen or cotton industry. In 1908 the proportion was 38 per cent. for piecers and 27.3 per cent. for other occupations.

These data are confirmed by those for mortality in the same districts. The effects of the work in wool spinning is, therefore, shown to be more deleterious to health than that in other occupations necessitating greater physical exertion. Thus, the number of deaths in Fourmies per 1,000 men of the same profession during the years 1900-1904, 1905, 1908 and 1909 during which the description of employment is unequivocal is as follows:

<table>
<thead>
<tr>
<th>Piecers and spinners</th>
<th>Other occupations</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 15-19 years</td>
<td>8.8</td>
</tr>
<tr>
<td>20-29</td>
<td>9.0</td>
</tr>
<tr>
<td>30-39</td>
<td>13.3</td>
</tr>
<tr>
<td>40-49</td>
<td>21.5</td>
</tr>
</tbody>
</table>

The mortality of piecers and spinners is higher from 15 to 30 years. Figures as to mortality from tuberculosis show that, as compared with an average of 50 per cent., that for piecers and spinners is 93 per cent. for the age period 20 to 29 years. (See the article "Textile Industries").

**Hygiene**

The British Woolcombing, etc., Regulations require that alpaca, peltian, East Indian cashmere, camel hair, and Persian cashmere shall not be opened except (a) after steeping in water or (b) over an efficient opening screen before any operation of sorting, which again must be done in a room set apart for the purpose. A sorting board shall not be deemed to be efficient unless 75 cubic feet per minute are drawn by the fan from beneath each sorting board. No sorting table may have a surface area less than 12 x 34 feet. Damaged wool (dead fleeces) shall be opened only by men skilled in judging the condition of the material and then washed without being willeyed.

Bales of ram mohair must be steeped before being opened. Alpaca, peltian, cashmere, camel hair, and Persian shall not be willeyed except in a room set apart for the purpose, and the willeying machine must be provided with mechanical exhaust draught so arranged as to draw the dust away from the workmen and prevent it from entering the air of the
properly constructed receptacles to be machines.

Cleanliness of the floor, walls and ceiling is enjoined; eating meals or changing clothes in the workrooms is forbidden; no person having any open cut or sore shall be employed. Means for ensuring personal cleanliness are required with provision for first-aid treatment of cuts or scratches.

In carding it is the "swift" which detaches the woollen fibres from the big drum. If the swift is well regulated and hooded over properly the workroom can be easily kept free of fluff. Arrangements have been thought out and applied for enclosing certain parts of the card to minimise escape of dust and fluff.

Viewing the industry superficially it might be admitted that the conditions from a health point of view are not bad. Apart from certain special points — grinding the cards, willeying, gassing — the workers are not exposed to risk from dust. Spinning rooms are large and spacious. Cubic space is ample — sometimes 100 to 150 cubic metres of air per person. But statistics tell their tale of working hours in the heat and humidity and a stagnant atmosphere. The practicable remedy already applied in many cases for securing good conditions without diminution in the temperature or saturation required is as follows:

(d) To have the factory built in such a way as to make it, as far as possible, independent of external influences so far as rooms are concerned in which the temperature must reach 20° to 25° C. and humidity 60 to 90 per cent., and not to allow the temperature considered necessary for good work to be exceeded.

(b) To have the air of the workrooms renewed so that the temperature and humidity remain within the limits fixed by experience as most suitable. Such ventilation, further, gives a margin before temperature and humidity become objectionable, and experience has shown that it is not attended by any fresh difficulty for spinning, while it does improve the atmosphere considerably from a health point of view.

Residual Waters

These waters are unpleasant, and undergo putrefaction and fermentation as they are rich in salts and in organic matter. To purify them one must commence at their source, for the processes vary according to the impurities present and the matter it is desired to extract.

The brownish black washing water contains the impurities soluble in water and grease. Wools classified as dangerous may contain anthrax spores. Waste waters from these ought not to leave the premises without previous disinfection. The soapy lye used in the removal of the grease flows away as a brownish yellow liquid containing in suspension or solution sand, excrement, wool fibres, emulsified grease, and the substances used in washing. This water used over and over again and concentrated in the form of mud can be burnt. The salts of the fatty acids are converted into carbonates — the fatty acids liberated are burnt.

If evaporation is carried on in open tanks evil-smelling, disagreeable vapours for the neighbourhood are given off. They should be carried away into a chimney stack with the gases from the furnace fires.

Extraction from the cinders is attended with certain dangers because, if not completely burnt, they give rise to evil-smelling vapours and dust irritating to the mucous membranes.

The suspended impurities in the lye waters are separated by sedimentation. The vegetable fibres are kept back by a sieve and used as cheap textile material. The lye then purified is subjected to a series of operations having for their object the extraction of the grease and the fatty acids. These substances are recovered by decomposing the lye by means of a mineral acid — generally sulphuric of 50-60° Be. The mixture is subjected to pressure and from the cakes obtained the fatty matters are extracted by various processes (hot pressing with acid solution). The crude grease is bleached with bi-chromate of potash and sulphurous acid. The residue is used as a combustible or subjected to volatile solvents. Solvents are also used for extraction.

The soluble soaps also can be converted into insoluble by means of caustic alkalis, which enables a soapy solution to be used over again for wool washing.

These processes expose the workers to several dangers: caustic action of the acids and alkalis, weather conditions; dust from the cinders, etc.

Cleanliness of the different working parts of the spinning frames and mules is essential. Friction of the sliver against the machinery it comes
into contact with detaches the fibres which stick there or fly round the machinery. When the fibres accumulate they can be taken up again by the sliver or constitute "beards" which revolve round the spindle. The combs similarly get choked as well as the covers and the brush below. Generally these parts are cleaned three times a day for material of first quality and as much as six times a day for the others. Finally, the gearing of the parts of the different machines, arranged at the ends of the spinning frame or mule, are cleaned once a week. Further, oiling must be regularly carried out by the "oiler".

To clean the combs the workwomen make use of a tool with a handle the extremity of which is equipped with a strip of card. The woman kneeling underneath the bobbin carrier applies the tool to the comb as it is travelling; to remove the fluff which soils the sleeves, the cleaners rub the surface of the leather with their hand or with another tool with a longer handle. The combs, the brushes and the rollers have the fluff which obstructs them removed after being uncovered. These operations often cause accidents from inattention; the cleaning implements, lightly held, are drawn into the spinning frame or mule, and instinctively the cleaner stretches out her arm to recover it. If the cleaner sees a plug lodged in the comb or a "beard" which will not come away with the brush, without thinking longer she tries to remove it with her fingers.

In removing or replacing the "casing" and rollers, the hand heedlessly is placed close to the point that is held for the casing, taken hold of and strikes a dangerous part. Or if the badly-replaced casing is about to fall on the comb the arm is rashly stretched out to catch hold of it.

Oiling is done with an oilcan having a long neck, the use of which would seem to be quite free of risk. But often the little holes for oiling are blocked. Then the workwoman puts a little oil on the end of her finger which she then places on the part to be oiled, at times very near the combs.

What tends to encourage these practices is that cleaning is easier and more quickly done while the machine is in motion, although this is forbidden by law.

The measures adopted as far as practicable to prevent these accidents or, at any rate, to reduce them to a minimum are:

(a) cleaning and oiling to be done by a trained workwoman over 18 years of age or by an old workman;

(b) use of automatic or semi-automatic methods of cleaning;

(c) guards for gearing wheels so arranged as to be removable except when the machine is stopped and requiring to be replaced before a start can be made.

**LEGALISATION**

Prohibition of the employment of young persons of less than 14 years of age in processes of deburring, willeying, dust extraction, unravelling, carding, combing, etc., unless dust is removed by mechanical means (Belgium); of less than 16 years from attending machines used for woolsorting, carding, and all processes in which injurious animal dust is given off (United States (Alabama, Arizona, California, Connecticut, Kentucky, Maryland, Massachusetts, Missouri, Ohio, New Jersey, New York, Tennessee, Wisconsin)); of less than 18 years from willeying, carding, cleaning, removal of vegetable debris by a wet method in which acid vapours are given off (France); of boys under 15 years of age in Italy from willeying, carding, cleaning, unless effective localised ventilation for the removal of dust is provided and maintained; of less than 16 years in Spain under like conditions to those in Italy; and from desalting waste wool by means of petrol, carbohydrates, etc., when poisonous fumes escape, from carding and cleaning in Canada (Quebec); and girls of less than 21 years in Spain and Italy under the same conditions as boys.

Women are prohibited from removal of vegetable debris from wool and cloth when done by a wet method if acid fumes are given off (France).

As to prevention of anthrax see the article "Disinfection of Wool." Cases of anthrax in persons employed in the woollen industry receive compensation in Great Britain and most of the British Dominions. In the Netherlands arsenical poisoning among persons employed in wool washeries is statutorily notifiable.

Special legislation on the woolen industry has been enacted in Austria (1922), India (1922), and in Great Britain to guard against anthrax infection. Great Britain has also issued Regulations dealing with sorting, dust extraction, washing, combing, and carding (16 December 1908, No. 1,929); on the use of wool coming from East India (18 December 1908, No. 1,887), and, further, in 1909, Regulations on the degree of maximum humidity to be permitted in spinning merinos, etc., by the French process (No. 1,114). Seats are required to be placed at the disposal of the workers during combing at night and during rest periods.

**BIBLIOGRAPHY**

This has pointed to the desirability of disinfecting the wool or hair prior to its use in industry, and measures with that object are in fact taken in various countries. Unfortunately it has been found that they cannot always be relied upon to destroy the infection without damage to the material, more particularly when applied in individual factories under variable conditions and with varying degrees of skill. These difficulties were considered in 1918 by a Committee appointed by the British Government to consider what further steps should be taken to prevent infection by anthrax in the manipulation of wool, etc.; and a new method of disinfection suitable for central disinfecting stations was worked out under the direction of the Committee. This method has been put into operation on a commercial scale and improved in various ways at the Central Wool Disinfecting Station established by the British Government at Liverpool; it has been markedly successful as regards both destruction of the anthrax spores and condition of the disinfected material.

The British Wool Disinfecting Station is a State organisation carried on under powers given by Parliament in the Anthrax Prevention Act, 1919, which enacts that provision may be made by Order in Council for preventing the importation into the United Kingdom, either absolutely, or except at specified ports and subject to conditions, of any goods infected, or likely to be infected, with anthrax. Powers are also given for the establishment of works for disinfection of such goods. An Order in Council made in 1921 (No. 352) under this Act prohibits the import into any port in the United Kingdom except that of Liverpool—and there only subject to the condition that such goods must be delivered to the Director of the Central Wool Disinfecting Station for disinfection—of all goat-hair from or through India and all wool and animal hair from or through Egypt. Such materials are, on arrival at Liverpool, taken charge of by the Customs and transferred to the Disinfecting Station.

In establishing any central station for disinfection of wool two considerations are of fundamental importance,
wool (disinfection) — 1272 —

i.e. (1) that in such an establishment the material handled may possibly be dangerously infected, with corresponding risk to the disinfecting station workers unless precautions are taken, and (2) that disinfected materials will be transported to factories in a condition of risk and will, therefore, be handled in industry without even such precautions against anthrax as it is possible to take in factories. It is essential, therefore, that the method of work should be such as to avoid contact with the raw material, or dust from such material, and that sterilisation shall be absolute in every case.

Anthrax spores in wool are frequently, perhaps usually, associated with albuminous substances in such a manner that they are afforded a considerable degree of protection. Consequently the process of disinfection must provide for the removal of such protection and the process of disinfection in use is accordingly arranged in three stages, in the first of which the spores are made susceptible to the action of the disinfectant, while in the second they are brought into contact with the disinfectant and killed, and in the third excess of disinfectant is removed from the material and the latter dried. In the actual carrying out of disinfection, which is a wet process, the bales of material are placed on a travelling platform and the coverings removed. The material itself is not handled, but is carried on the moving platform into a machine where it is sufficiently loosened to permit it to be fed by machinery at a predetermined rate into the first solution. The considerable quantity of dust which escapes in this operation is extracted by fans and conveyed automatically to the boiler furnaces and there burnt.

The actual disinfecting plant consists of five bowls or baths of the type used in wool washing, each of which contains a solution maintained at a temperature of 102°-110° F. (39°-44° C.) through which the material is to be disinfected is propelled by means of reciprocating forks at such a rate that it remains in contact with each solution for ten minutes. The material is passed through squeezing rollers at the end of each bath in order to remove air bubbles and excess of liquid and prevent dilution of each succeeding solution.

The first of the five baths contains a solution of sodium carbonate in water, the strength of which varies according to the type of material being disinfected, but is normally about 4 per cent.; and the second contains a solution of soap in water of a strength of approximately 1/2 to 1/4 per cent. The treatment in these two baths constitutes the preliminary part of the process in which the albuminous protection of the spores is removed and the spores made susceptible to the action of disinfectants, and each bath is provided with: (1) apparatus for removing from the solution the dirt and foreign matters washed out of the wool, and (2) apparatus for automatically adding sodium carbonate and soap in order to maintain the strength of the solutions.

The third and fourth baths each contain a solution of formaldehyde in water of a strength of approximately 2 per cent., and they are completely enclosed in order to prevent escape of formaldehyde into the air. These two baths are connected with a common system of purifying plant in order that the solution may be cleansed of foreign matters and used over again, and to each is fitted apparatus for automatically adding formaldehyde to the solution in order to maintain its strength, as, especially in the third bath, it is being constantly diluted by the water carried on the wool from the preliminary treatment.

The fifth bath contains a very dilute solution of formaldehyde and to it fresh water is being added constantly in order to keep its strength down to approximately 0.2-0.3 per cent. of formaldehyde, since its purpose is to remove excess of formaldehyde from the wool. After leaving this bath the wool is carried by rollers into a duct, through which it is driven by means of a current of hot air at a temperature of approximately 240° F. (116° C.) into a wool-drying machine. The volume and temperature of the current of air are so arranged in relation to the quantity of material carried by it that, by the time the material reaches the drying machine, the temperature, as a result of evaporation of the moisture in the wool, is reduced to approximately 160° F. (60° C.). Following the drying machine is: (1) a cooling machine in which the temperature of the wool is reduced to that of air, (2) a machine by which moisture is added to the wool to bring it to the standard condition of moisture content accepted in commerce, and finally (3) a baling press, in which the wool is made up into pressed bales of convenient size.

The machines are arranged in sequence, and the speeds of each part are so regulated that the material passes automatically through each, and from one to another, at exactly the same rate, with the result that in normal
conditions it forms a continuous band from one end of the plant to the other, and it is unnecessary for any person to touch it (except so far as may be incidental to removal of the bale coverings of the raw material) from the time it enters the machines to the time it is baled again after disinfection. The rate of disinfection is approximately 2,000 lb. per hour per machine.

The costs of running the Disinfecting Station are borne by the Government, but are partly covered by a charge made for disinfection, which is in accordance with a statutory scale (Statutory Rules and Orders, 1921, No. 1044), i.e. 1d. per lb. for material losing up to 20 per cent. in the course of disinfection, 1½d. per lb. when the loss is over 20 per cent. and not more than 50 per cent. and 1½d. per lb. when it exceeds 50 per cent., in each case calculated on the weight of raw material.

Careful control of the whole process is essential, since, being continuous, the strength and temperature of the solution varies from moment to moment, and it can be calculated that accurately as soon as the flow of the strength of the formaldehyde solutions may be reduced below the disinfecting strength in from three to five minutes by the introduction of water carried by wool from the preliminary process. Temperatures are controlled by means of thermometers readings made at fixed intervals by the machine minders and entered on a daily report. These are checked by the chemist in charge, also at fixed intervals, and recorded on an independent report. Strengths of solutions are maintained by means of automatic addition apparatus, which can be adjusted as required, and the solutions themselves are analysed at fixed intervals, the results being recorded on the chemist's report and at once communicated to the machine minders in order to afford data for adjustment of the automatic addition apparatus. Condition tests on the disinfected wool are also made to make sure that it is being sent out as nearly as possible in commercially accepted condition in regard to moisture content.

In addition to the expert control of strength and temperature of solutions, careful bacteriological control is maintained. Samples of the raw materials before disinfection and of the disinfected materials are taken at intervals of approximately three hours, those of disinfected material being taken one and half hours after the corresponding raw material samples, in order to secure comparative samples, since material requires approximately one and a half hours to pass through the process. The bacteriological examinations are not made in the Disinfecting Station or under the control of the Station authorities. Some samples are sent to the Public Health Laboratory of Bradford, some to that of Liverpool, and some to a bacteriologist retained by the Home Office, who report the results they obtain.

Wool and hair contain spores of many organisms, usually non-pathogenic, in addition to spores of anthrax, and one of the most widely distributed, bacillus mesentericus, is considerably more resistant to destruction than even anthrax. In order to ensure that the disinfection is maintained at a high standard of efficiency, an empirical standard has been evolved to which if the cultivation from a sample of disinfected material of more than five colonies of such "other" organisms is reported, careful enquiries are made as to the cause. Even though these may not point to any defect in the method of destroying anthrax, the constant possibility of enquiry resulting from this method of control ensures a high standard of working efficiency.

It will be seen from the table giving the results of bacteriological examination of samples of material disinfected in the Disinfecting Station (page 1274) that only two samples of disinfected material have been found to contain anthrax; these were taken soon after the disinfecting station was started and were traced to known defects of control, and no instance has occurred since, so it can be assumed that disinfection is complete. It will also be observed that the degree of infection varies considerably in different raw materials, but on the average somewhat less than 10 per cent. of all the material handled in the disinfecting station is infected with anthrax, while nearly 70 per cent. of the disinfected material is completely sterile.

It may be urged that the establishment of a central disinfecting station merely transfers the risk of contracting anthrax from the workers in factories to those at the Station, but such an argument is fallacious. In particular, it is possible in an establishment specially designed and carried on...
RESULTS OF BACTERIOLOGICAL EXAMINATIONS OF MATERIALS DISINFECTED IN THE GOVERNMENT WOOL DISINFECTING STATION (HOME OFFICE), LIVERPOOL, FROM OPENING OF STATION JUNE 1921 TO 31 AUGUST 1929

<table>
<thead>
<tr>
<th>Material (Imported from or through the country named)</th>
<th>Raw material</th>
<th>Disinfected material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total samples examined</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>India:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>136</td>
<td>9</td>
</tr>
<tr>
<td>Goat Hair</td>
<td>1,270</td>
<td>196</td>
</tr>
<tr>
<td>Iraq:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>101</td>
<td>14</td>
</tr>
<tr>
<td>Goat Hair</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>Asia Minor, Syria and Palestine:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Camel Hair</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Mohair</td>
<td>13</td>
<td>—</td>
</tr>
<tr>
<td>China:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goat Hair</td>
<td>33</td>
<td>2</td>
</tr>
<tr>
<td>Horsehair</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>Russia and Siberia:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Goat Hair</td>
<td>18</td>
<td>—</td>
</tr>
<tr>
<td>Horsehair</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>Africa:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goat Hair</td>
<td>29</td>
<td>1</td>
</tr>
<tr>
<td>Egypt:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>883</td>
<td>60</td>
</tr>
<tr>
<td>Animal Hair</td>
<td>92</td>
<td>—</td>
</tr>
<tr>
<td>South America:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpaca and Llama Hair</td>
<td>201</td>
<td>2</td>
</tr>
<tr>
<td>Wool</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Horsehair</td>
<td>7</td>
<td>—</td>
</tr>
<tr>
<td>Various origins:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drawn Bristles.</td>
<td>60</td>
<td>—</td>
</tr>
<tr>
<td>Totals:</td>
<td>2,044</td>
<td>276</td>
</tr>
</tbody>
</table>

*In the early period of disinfection, before complete routine control of the disinfection process was fully established.
for disinfection purposes to take precautions which would be impossible or ineffective in an ordinary factory, and experience at Liverpool shows that the risk is quite small.

The material compulsorily disinfected is mainly used in Bradford and district, and the incidence of anthrax there as well as the severity of the disease have greatly decreased since the establishment of the Disinfecting Station, though some materials, e.g. Persian wool, etc., are not required to be disinfected compulsorily. The following table, drawn up from particulars supplied by the Bradford Inspector of Factories, shows the incidence of anthrax in Bradford and district in the nineteen years 1902 to 1921 before disinfection was established, and in the eight years 1922 to 1929 since:

<table>
<thead>
<tr>
<th>Period</th>
<th>Total cases</th>
<th></th>
<th>Fatal cases</th>
<th></th>
<th>Pulmonary cases</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Yearly average</td>
<td>Number</td>
<td>Yearly average</td>
<td>Number</td>
<td>Yearly average</td>
</tr>
<tr>
<td>1902-1921</td>
<td>242</td>
<td>12.7</td>
<td>73</td>
<td>3.8</td>
<td>31</td>
<td>9.7</td>
</tr>
<tr>
<td>1922-1929 (Sept.)</td>
<td>34</td>
<td>4.3</td>
<td>5</td>
<td>0.6</td>
<td>2</td>
<td>0.25</td>
</tr>
</tbody>
</table>

In no case has infection been traced to disinfected material, but in a large proportion infection has definitely been traced to materials which have not been disinfected.

It is generally considered that there is some occupational risk in handling formaldehyde, which is used in disinfection of wool. Experience of disinfection seems to indicate, however, that this is very small. No case of illness due to this cause has occurred among the workers, though two mild cases of an eczematous condition of the skin have been observed. The workers concerned were, however, occupied in remedying special defects of the plant, during which they were in close contact with the formaldehyde solution used and no affection resulting during normal working has occurred.

Some discomfort amongst workers handling disinfected wool was at one time reported as being due to the escape during manufacture of formaldehyde retained in the wool. Enquiries showed that this was justified and that there was definite discomfort and possibly some risk from this cause. At that time no steps were taken to remove formaldehyde from the wool, but as soon as the effect was observed special measures were taken to render disinfected wool free from formaldehyde, since which time no trouble has arisen.

The central disinfection of wool involves, of course, important economic considerations which cannot be dealt with in the scope of the present article, but mention may be made of a report recently issued (1923) by a Committee appointed by the British Government to enquire as to the additional charge to the industries using East Indian wool which would result from its disinfection as carried out at Liverpool. This report indicates that if disinfected East Indian wool were used in place of undisinfected in the manufacture of carpet yarns and felt the additional cost would be not more than 1d. per lb. of carpet yarn and not more than 1d. per lb. of felt. This is equivalent to an increase in the cost of carpets and carpet felts of slightly more than 1d. per yard.

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Report of the Departmental Committee on Disinfection Costs appointed to enquire as to the probable charge to the Industries in which East Indian Wool is used of requiring all such Wool imported for use in this Country to be disinfected under the Government’s Disinfection Scheme on arrival in this Country; and to carry out such Tests as may be found necessary. 2 Vols. London, H. M. Stationery Office, 1923.

*Dr. G. E. Duckering, O. B. E.*

(Liverpool)
Xylene

French: Xylène; Xylol. — German: Xylol. 
Italian: Xilolo. — Spanish: Xileno.

Xylene, dimethylbenzene \((C_6H_5(CH_2)_2)\), a hydrocarbon obtained from tar, is a mixture of three isomers, \(O\), \(M\), and \(P\), the meta being present to the extent of 70 and 80 per cent. As their boiling-points are slightly different, it is impossible to separate them by fractionated distillation. Industry uses more especially the metaxylene, of which two kinds may be distinguished, the crude liquid, colourless or yellowish xylene, boiling between \(120°\) and \(150°\) C., and the purified colourless liquid xylene, which boils between \(120°\) and \(145°\) C., and even between narrower limits. These two products, however, still contain more or less considerable quantities of toluene, traces of thiophene, ethyl and trimethylbenzene, paraffin hydrocarbides, etc.

The principal source of xylene is coal-tar. The second series of products obtained by tar distillation and given off from about \(110°\) and \(170°\) C. consists of light oils of fairly variable composition which give, on fractionated distillation, light and heavy benzols. Subjected anew to fractionalized distillation, these two series give seven different series, boiling at varied temperatures; crude benzois which after several kallian and washings and several rectifications in order to free them from phenols, provide various trade products of benzene, toluene and xylene.

By reduction of xylene there can be obtained aminated derivatives called xylidines, homologues of aniline, which are used in the manufacture of colours, explosives and varnishes. The nitration of xylene gives nitro-xylenes, which, however, are not very extensively used in industrial technique. The xylenes are used as solvents for oils, fats, waxes, colours, etc., and as cleaning products, etc.

The toxic action of xylene is similar to that of benzene and toluene. Nevertheless, according to Lehmann, commercial xylene is said to be one-fifth more toxic than benzene; narcosis sets in more rapidly and recovery is slower.

This fact has been established as a result of experiments effected on animals (Koelsch): 43 mg. of xylene per litre causing narcosis at the end of forty minutes (Rambousek); 4.3 mg. per litre irritated the mucous membranes and provided derangement of equilibrium (Batchelor). In man, poisoning is manifested by paresthesias, trembling, a feeling of oppression, vertigo, headaches, loss of memory, weakness, insomnia, cardiac, respiratory and visual affections, etc. In the cases encountered, poisoning did not give rise to permanent injuries.

The nitro derivatives of the xylenes \((C_6H_5(CH_2)_2NO)\) are of less practical importance; the five isomers are mixed at a high boiling point used for preparing xyldine, which has an action similar to that of nitro-benzene, though however less marked. The animal experiments carried out by Ilzhöfer (1918) with trinitroxylene utilised in the explosive industry have proved the absolute harmlessness of this product.

The animated derivative, xylidine \((C_6H_5(CH_2)_2NH)\), obtained by reduction of nitroxylene, is a mixture of \(m\).-xylidine \((40-60)\), para-xylidine \((10-20)\), the remainder being made up of the three other isomers. Poisoning recalls that caused by aniline, but it is said to be characterised by a sensation of heat in the face, headache, etc., of very early occurrence.

During the war, the bromides of xylene and xylidine were used as tear gas under the name of "T-Stoff".

A cleaning product placed on the market under the name of "xylol", and containing also toluol and benzol, has been the cause of several cases of poisoning amongst workers engaged in helio-engraving (see articles "Printing Trades" and "Photo-Engraving"). As regards hygiene and legislation see article "Benzene".

Injuries due to xylene are subject to compulsory notification in the Netherlands, and entitle victims to compensation in Finland and Italy.

See also articles "Benzene" and "Nitro-Amide Derivatives of Benzene and its Homologues".

Dr. R. Fischer
(Berlin)
Zinc


Zinc (symbol Zn) is a greyish-white metal, with a strong metallic lustre and a finely granulated appearance which is crystalline or lamellar, according to the method of preparation; the melting point for the purest zinc (99.99 per cent.) is 419.4° C., and the boiling point 930°, which is the lowest point for heavy metals, with the exception of mercury. It is very stable in dry air and pure water; but in damp air it becomes covered with basic carbonate of zinc, which protects it against further corrosion. When heated to 500° C., zinc burns with a greenish-blue flame, giving off oxide of zinc. Powdered zinc, which is used as a powerful reducing agent, decomposes water even at ordinary temperature, with the formation of hydrogen and a great emission of heat; hence arises danger of spontaneous combustion in damp store houses.

Commercial zinc, as opposed to pure zinc, dissolves easily in dilute acids, and with difficulty in alkalis, with the formation of hydrogen.

INDUSTRIAL OPERATIONS

Brass, the most important alloy of zinc, as well as its manufacture from copper ores, was known to the ancients before zinc. Imported in the sixteenth century from Eastern Asia, as Indian tin, its commercial manufacture only began in Europe towards the middle of the eighteenth century, and, on a large scale, only after the elaboration of the modern process with muffle furnaces in 1798.

Zinc is very widely distributed in nature in the form of ores composed of sulphide or oxide of zinc, which almost always contain cadmium, from 0.1 to 5 per cent., as well as such other heavy metals as iron, manganese, lead, copper and silver. The most important ores of zinc are the following:

Sulphide of zinc (ZnS), known as blende or sphalerite, contains in its pure state 67 per cent. of zinc and 33 per cent. of sulphur. Some varieties contain lead oxide and silicides of iron and copper, such as Marmatite, Christophite and Wurtzite.

Calamine (SiO₂Zn₄H₂O) is a hydrated silicate of zinc which contains in its pure state 53.7 per cent. of zinc; the trade variety contains 25 to 35 per cent.

Smithsonite (ZnCO₃) is a carbonate of zinc containing 52 per cent. of zinc in a pure state, and 35 to 45 per cent. in the case of the trade variety.

Auricalcite is a variety of Smithsonite which contains copper; another variety is hydrozincite, which is a basic carbonate of zinc. Willemite, an orthosilicate of anhydrous zinc, and Gahnite, or zinc aluminate, should also be mentioned.

It must, however, be remembered that Calamine and Smithsonite are very often mixed, and that they then form a type of ore with stalactite and mamilloform appearance, classified by mineralogists under the generic name of “Calamines”.

Zinc oxide (ZnO) is found in the form of red zinc, zincite, spartalite, with 70-80 per cent. of zinc, or as Frank lime (FeMnZn (FeMn)₂O₄), a black mineral, frequently associated with red zincite and yellow to green Willemite, which is almost free from lead, but rich in iron and manganese, and contains about 18 per cent. of zinc.

Cadmia is an industrial ore formed of the dust deposited on the upper part of blast furnaces; it consists of zinc oxide coloured by a little oxide of iron.

Poor zinc ores, with only 20-25 per cent. of zinc, are subjected prior to treatment, to sorting and mechanical processes for enriching the ore, so as to obtain a zinc content of at least 35 to 45 per cent. The operations are almost always done by wet methods, either in special machines or by “floatation”; only rarely are electromagnetic or electrostatic methods of separation employed. The ores thus “concentrated” are changed, as far as is pos-
sible, on the spot or in foundries, by roasting or calcination, into zinc oxide, which has, in its turn, to be subjected to reduction. Ores with a base of carbonate or silicate of zinc are heated with charcoal in calcining furnaces, which are, in a way, similar to lime-kilns. On the other hand, sulphide ores must have the sulphur completely removed, which is easier with ores rich in zinc than with those poor in zinc. The process is carried out by the formation of zinc sulphate which, above 900° C., decomposes into zinc oxide and sulphur dioxide; blende, which contains lead and lime is, on the contrary, not readily deprived of its sulphur.

The roasting, or calcining, of sulphide ores is done in furnaces similar to those used for pyrites. Conveyors or telferspans charged in the silos carry the ore to the different apparatus, which makes it possible for the workmen to avoid all exposure to the action of dust, heat radiation and the gases given off by the roasting, and, especially, the sulphurous gases which are used to prepare sulphuric acid.

After roasting or calcining, ores containing zinc in the form of oxide or silicate are subjected to reduction with charcoal. This operation is carried out at about 1,100° C., that is to say nearly 170° C. above the boiling point of metallic zinc. The reduction of zinc oxide is not due to the charcoal, but to carbon monoxide, according to the following reaction: \( \text{ZnO} + \text{CO} = \text{CO}_2 + \text{Zn} \).

Reduction is always accompanied by distillation and to prevent the zinc fumes taking fire on contact with the air, or entering into reaction with the carbon dioxide from the combustion gases, closed retorts are used, in which is placed a mixture of ore with an excess of charcoal. The measures used to effect the reduction of zinc oxide and the distillation of metallic zinc vary in different countries.

According to the Belgian method (see fig. 205), the reduction is done in slightly conical retorts made of refractory fire-clay, 1 to 1½ metres in length, with a diameter of 15 to 20 cm. These retorts communicate at the front with a fire-clay condenser, so curved in shape that the lower portion forms a cup or basin into which the smelted zinc distils. The other end of the condenser terminates in a cylindrical sheet-iron cover or protection, which is constructed so as to favour the condensation, in the form of grey zinc dust, of fumes which escape from the curved condenser (see fig. 208). The retorts are placed in the furnaces in groups of eight to ten, superimposed pair by pair. Each furnace contains a number of retorts, which may vary from 150 in Belgian furnaces to 700 in American furnaces. The furnaces are heated by means of gas from gas generators; and combustion occurs in an atmosphere of hot air, which is introduced from heat recuperation chambers.

The distilled zinc is removed from the basin of the condenser every two or three hours by means of an iron spoon. When the distillation is finished, the residue from the retorts, which contains 3 to 5 per cent. of zinc and, very often, a much greater quantity of lead, is drawn out with iron rakes and used for the manufacture of lead. The grey zinc dust consists of finely divided zinc, the granules of which are covered with a thin coating of oxide; it is put back into the retorts to be re-distilled.

In the Silesian process (see fig. 207), which differs only slightly from the preceding, muffles made of refractory
fire-clay are used, which communicate with a condensing apparatus by a tube and are heated in a reverberatory furnace. The zinc condenses in the condenser in a liquid state, in which form it is run into moulds. Each muffle furnace has in front two openings, a lower one for extracting the residues of distillation, and an upper one for charging.

It is now some time since a successful endeavour was made to replace horizontal retorts, the action of which is intermittent, by vertical retorts with continuous charging according to the process of Roltzheim and Rémy; by these means the technical and hygienic disadvantages, associated with manual work at the intermittent furnaces, are done away with. The charge, after preliminary heating, is put into the upper part of the retorts, and the residue from the distillation, when cool, is removed mechanically at the lower part. The retorts, which are open at both ends, are closed, during charging, by the mixture which is introduced, and, also, at the opening for discharge by the residue. Each retort is connected with an elongated condenser which is bent perpendicularly on its axis.

In countries where electric power is cheap, such as Sweden and Norway, the reduction of oxide of zinc is done in a special furnace, the crucible of which is heated internally by an electric arc. This is the process of electro-thermic reduction and distillation.

The preparation of zinc electrolytically has been carried out according to two methods: (a) separation of zinc vapour in an atmosphere of carbon monoxide and condensation of this vapour in the form of liquid metal; and (b) condensation of zinc vapour in the form of dust and its fusion by electricity.

Complex sulphide ores may also be treated, after careful roasting, with sulphuric acid, which causes the precipitation of lead, silver, copper and most of the iron. The zinc which passes into solution, in the form of sulphate, is first purified by precipitation and filtration, and then subjected to electrolysis in a bath the tension of which is about 4 V. The residues are used for the preparation of lead.

With the exception of cases where ores poor in lead are used, ordinary metallurgical processes give a product
The present time alloys rich in zinc, up to 55 to 93 per cent., are used as metal coatings in plating (the metal "tenax" contains 92 per cent.; the Spandau alloy contains 89-93 per cent.); as a substitute for brass in the manufacture of armatures, cartridge cases, capsules, and in artistic foundry work. Lead is often added to brass and other alloys of zinc in the proportion of 1 per cent, or more to facilitate the working of turning and cutting.

In the manufacture of lithographic plates a thin layer of zinc amalgam is spread on the surface as a reducer, and the plate is then heated in suitable furnaces. In the textile industry large quantities of zinc powder are used for printing, and dyeing in hydro-sulphite vats.

### Compounds of Zinc

Oxide and sulphide of zinc are used as white pigments, but only the latter is used with sulphate of barium in the preparation of lithopone (see that article).

Oxide of zinc (ZnO; snow white, China white) was suggested as a substitute for white lead for the first time in 1780 by Courtois, of Dijon. Since 1786 it has been manufactured on a large scale as a pigment the use of which continues to increase.

The two processes for the manufacture of zinc oxide in actual use are the sublimation, or indirect process, and the direct process.

The first consists in combustion of the metal, which is put into retorts of refractory material arranged in a laboratory furnace, heated to 1,300 or 1,400° C.

The melted zinc, under the influence of heat, distils, giving off zinc fumes, which, in front of the partition where the retorts open out, meet a current of hot air, the oxygen of which combines with the zinc to form zinc-white or oxide of zinc. This is brought by a system of iron pipes into canvas chambers, the sides of which allow the gases to filter through, while they retain the oxide, which is collected in canvas sleeves fitted to the bottom of the chambers.

The finer and whiter oxide is collected at the far end of the chambers, whilst at the entrance the collected product is denser and not so white. The product naturally varies, as much from the point of view of colour as from the point of view of chemical composition, according to the metal used for charging, whether pure zinc, ordinary zinc, old or matte zinc.

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By this process whites of great purity are obtained; a content in oxide of zinc which may reach 99.5 per cent. is easily obtained, even from relatively impure zincs; with zincs made electrolytically a percentage of 99.97 is reached.

The content of lead in zinc white obtained by sublimation is lower than 0.02 per cent. for the whites of high quality; it does not exceed 0.2 per cent. for those of ordinary quality.

In the direct process, zinc white is made by treating zinc ore or materials containing zinc direct, without first extracting the metal; the cost price is lower than that of white obtained by sublimation.

Furnaces are used, the vaulted masonry chamber of which is divided by a fixed grating formed either by a perforated plate, in the Wetherill type, or by ordinary gratings having between the bars a space of some millimetres.

A strong current of air sent below the grating, which surrounds the ash-hole, traverses the mixture of ore and fuel and makes it red hot. Reduction of the metal occurs in the interior of the mass, and the vapours given off become oxidised in the chamber (laboratory) on contact with carbon dioxide and oxygen in excess.

Often the gases coming off from the actual furnace are brought together in a collector made of refractory material set upon a block of masonry; by the help of the surrounding temperature and closer mixing of the gas, the vapours of zinc there become completely oxidised. The gases are cooled by passing through iron tubes, and the oxide of zinc reaches a system of canvas sleeves.

The raw materials should only contain a small quantity of such chromogenic metals as cadmium, antimony and tin. In the United States, Willemite and Franklinite are used with advantage.

The lead contained in the ore passes in large part into the white, and most of the ores give an oxide which exceeds in content of 2 per cent. of lead; while for some direct whites, it reaches even 10-15 per cent.

However, manufacturers of direct make use of different methods by which the lead of the ore may be removed before or after treatment of the finished product. A recent method (1931) for the production of zinc white, is that of the revolving furnace, "Wälzverfahren", in which residuary materials hitherto regarded as unusable are treated.

Calcination of the basic carbonate of zinc also gives a white powder which has been wrongly called "zinc white"; it is used in varnishes because it possesses a good covering power.

By calcining oxide of zinc (88 per cent.) and oxide of cobalt, zinc green, cobalt green or "Rimman green" is obtained.

Zinc white, which is not toxic, possesses good technical qualities as a pigment, including a covering power almost equal to that of white lead, and resistance to sulphuretted hydrogen and light. Its wearing capacity comes between lithopone and white lead (see article "Painting"). Zinc white is also used as a product for filling in and colouring products of rubber, linoleum, or imitation leather.

Zinc grey, which is a by-product of the manufacture of plumbozinc white, is used as well as zinc powder in anti-rust paints for metals.

Zinc yellow is a double chromate of zinc and potassium. Zinc sulphate (ZnSO₄·7H₂O; vitriol of zinc) is found in the native state as zincsite, white vitriol, Galician stone and goslarite; it may be obtained by dissolving zinc or zinc residue in dilute sulphuric acid, or heating zinc sulphide to red heat and then dissolving it in warm dilute sulphuric acid. The slime of zinc which forms in the manufacture of hydrazobenzene can also be changed into zinc sulphate (see article "Benzidine").

Zinc sulphate is used chiefly for the manufacture of lithopone (see that article) and some other mineral pigments, as a mordant for preserving skins and wood; for rendering textile fabrics non-inflammable; and as a disinfectant.

Zinc hydroxysulphite (Zn₃(NH₃)₂(SO₄)·2H₂O) is used as a reducing agent in dyeing with indigo.

Zinc chloride (ZnCl₂; butter of zinc) is a white, very hygroscopic, deliquescent powder, highly soluble in water; it extracts water from organic substances up to the point of carbonising them. Chloride of zinc is prepared by dissolving zinc residue, oxide of zinc, as well as calcined zinc ores, in dilute hydrochloric acid, and evaporating the solution, or by heating zinc in a current of chlorine. The concentrated solution forms, with zinc oxide, a mass which hardens rapidly as oxychloride of zinc.

It is used for the preparation of soldering salt, mixed with chloride of ammonium; in the carbonization and impregnation of wood; as a disinfectant, for preserving certain dead animals; for preparing parchment paper; and as a condensation agent in the chemical industry.
Under the name of "Cryptone CB 21" there has recently, since 1931, been put on the market a sulphide of zinc, which seems to be very useful for the preparation of opaque colours, with a very high covering power.

Zinc phosphide ($\text{Zn}_3\text{P}_2$) is obtained by heating zinc powder in the presence of phosphorus fumes or by heating a mixture of zinc powder and red phosphorus in a current of hydrogen and illuminating gas. This phosphide has a grey metallic appearance, with an odour of phosphorus in a current of hydrogen and heating zinc powder in the presence of covering power. It decomposition in the presence of acid, giving off phosphuretted hydrogen. A phosphide ($\text{ZnP}_2$) in the form of reddish-yellow crystals is also known, which, when heated, becomes red.

The first-mentioned phosphide is now much used in the country in the campaign against rats and rodents.

**Sources of Dangers**

During metallurgical operations, and during the preparation and use of compounds of zinc, the sources of dangers are represented chiefly by substances and impurities present in zinc ores with the metal or its compounds, rather than by zinc itself. High temperatures, such furnace gases as sulphur fumes and carbon monoxide, as well as dust, represent other sources of injury in the course of various industrial operations. However, occupational poisoning by zinc, beyond the special case of brassfounders' ague, is unknown; lead poisoning in the zinc industry is, on the contrary, common; but poisoning by arsenic is rare (Gibert).

Nowadays, thanks to the greatly extended use of muffle furnaces, sulphur fumes are recuperated and utilised. In addition, the work of smelters, especially at roasting furnaces of old type, calls for great expenditure of muscular force. Other very fatiguing processes which are also associated with exposure to heat, to gases rich in carbon monoxide, and to dust, are tending distillation furnaces, the management of the condensers, the emptying of the residue and cinders, and the melting of the crude zinc. Work at the furnaces exercises an unfavourable effect on the general health of the workers, and encourages the development of "a friare" diseases, e.g. rheumatism, respiratory diseases and symptoms of early wear-and-tear. Dermatitis of a pustular type has been noted quite often, especially in summer; it is due to blocking of the sebaceous glands with dust; it appears on the interior surface of the thighs and in the axillae. Similar skin affections have been also described in zinc oxide works by Turner in 1921.

Furnace workers also show affections of the conjunctiva, due to dust and radiant heat; and those who work at the distillation furnaces experience visual disturbances (hemeralopia) caused by the glare.

But the most serious danger which threatens the workers at zinc foundries, or spelter works, is that which arises from lead poisoning. This hazard is often of the same severity as in the metallurgy of lead, since almost all zinc ores have a high content of lead which, in some blends, amounts to 20 per cent, and sometimes is as high as the content of zinc. In mines, and during wet processes for preparing zinc ores, which contain lead in the form of sulphide, risk of lead poisoning is almost negligible. On the contrary, lead given off during roasting in the form of oxide, which readily becomes dusty, represents a serious hazard for men employed at the furnaces. It is usual, after cooling the products from roasting, to wet them thoroughly, by which the raising of lead dust is much reduced. Mixing the product from roasting with coke is only harmful when done by hand in a dry state. Risk of lead poisoning is much more important during work at the distillation furnaces when scouring the condensers, or drawing the residues in which the lead content may reach 10 per cent.; indeed, for this reason it sometimes happens that the residues are used in the metallurgy of lead. Some former investigations carried out where Silesian furnaces were used for distilling zinc in spelter works disclosed the presence of 6 per cent. of lead in the dust.

In the same way, the dust, which constitutes 5 to 10 per cent. of the total zinc collected, is rich in lead, 1.3 to 3.3 per cent. in Germany; 1.9 to 2.44 in Belgium; traces up to 5.2 per cent. in the United States. Considerable dust is sometimes given off when the condensers are tapped, and also during sieving and barrelling. R. P. Batchelor and his fellow workers in 1926 found, in an American smelting works, 108 mg. per cub. metre as a maximum amount; but in this case, the zinc dust was free from lead. The danger of lead poisoning is very great when the broken fragments of the muffles are utilised in the preparation of new furnaces, since scraping off slag rich in lead and crushing the fragments give rise to dust containing lead.
The lead risk is less serious during the refining of crude zinc and the use of zinc having a percentage of 1.2 in lead. If, however, the refining is done by the direct process with residues very rich in lead, then the risk of lead poisoning is very considerable (Lehmann, 1928).

The only trouble which can be attributed to zinc is founders’ ague (see below), which attacks almost exclusively brassfounders, generally during the preparation of varieties rich in zinc. More rarely, it attacks founders of “new silver” containing 16.24 per cent. of zinc, or of bronze. As indeed the first authors to describe founders’ fever (Blandet, Greenhow) remarked, this morbid condition depends on the fact that the melting point of the alloy with copper, 1,083° C., reaches, or indeed exceeds, the boiling point of zinc, 905° C.; in consequence, great quantities of zinc oxide fumes rapidly liberated as a result of volatilisation of zinc become oxidised on contact with air. This evolution of zinc fumes is particularly important, during brassfounding, when the alloy is prepared by first melting the copper and then adding the solid zinc to the product, melted at a temperature of about 1,150° C. In this case, the zinc, raised forthwith to a temperature higher than its boiling point, is subjected to combustion and rapid volatilisation. If, on the contrary, the alloy is first melted, or, if the two metals are mixed after being melted, the temperatures of melting and boiling are then found between those for the two separate metals; this condition is complied with when founding zinc or alloys very rich in zinc, such as metals for forming a subcoating in electroplating, and the metal “tenax” with more than 90 per cent. of zinc.

Founders’ ague is exceptional among men employed at distillation furnaces; it is commoner among those who work at electro-thermic distillation; and it may be observed quite often among those employed in soldering and cleaning with the oxyhydrogen or oxyacetylene flame sheets of galvanized iron, because, during these operations, the temperature exceeds 1,500° C. and causes volatilisation and combustion of the zinc (Engelsmann); and also among those who do zinc plating by means of the spray gun, and among those who empty and clean the piping. On the other hand, the disease is not seen during the melting of zinc or galvanising (Nuck, Rémy, Holtzmann).

The use of zinc in the form of residues or powder, as a reducing agent in the chemical industry, or in acid or alkaline solution in the coal-tar dye industry, exposes workers to risk of poisoning by arseniuretted hydrogen, in consequence of the presence of arsenic in the zinc and the mineral acids used. In the same way, the preparation of “cementation copper” with zinc waste and iron covered with granulated zinc, that of zinc sulphate from zinc residues or from roasted zinc ores and from products of roasting silicious ores containing zinc, may cause poisoning by arsenic hydrogen.

Practice and experiment have proved that this gas is given off when zinc utensils are used for cleaning iron receptacles for acids.

The general conditions of work in factories making zinc oxide by the direct method resemble those for the metallurgy of zinc.

**TOXIC EFFECT**

From the toxicological point of view, the analogy between zinc and copper is so marked that these two elements may be placed in a special pharmacological group, although they belong to groups of chemically different heavy metals. Soluble salts of zinc precipitate albumen and exercise in consequence, depending on their concentration, a local effect, caustic or astringent, and a general effect, due to absorption which is of quite secondary importance. In the same way there is a
ZINC... 1284...

possibility of these salts being resorbed by the digestive organs, for they have a marked emetic effect. Kobert systematically distinguishes such soluble salts of zinc as the sulphate and chloride, with a purely local caustic action, from the non-caustic salts which are capable of exercising a general effect by absorption, with paralysis of the central nervous system, and of the vascular system and the muscles.

It should be said, however, that this distinction has a theoretical importance rather than a practical one, for it is only under special experimental conditions of intra-venous or subcutaneous injections of complex zinc compounds which do not precipitate albumen, that symptoms of general acute poisoning may be provoked. Hofmeyer caused the rapid death of an animal by injecting into the circulation albuminate of zinc, which, according to Kunkel, is fatal in a dose of 28 mgr. per kilogram given by the alimentary canal.

Cases of poisoning, accidental or intentional, caused in man by the absorption of zinc chloride solution are always characterised by serious necrosis of the mucous membranes, vomiting, gastro-enteritis, and, sometimes, by fatal collapse. Digestive disturbances also predominate in cases due to insoluble compounds of zinc (oxide); but they have been observed more rarely in man. According to Spillmann (1883) and J. Macht (1931), the absorption of 10 grm. of zinc oxide causes vomiting and gastric pains; but when it was used therapeutically years ago, and doctors prescribed it in a dose of 25 cg. daily as a sedative and anti-epileptic, it found pallor, anaemia, paresis and muscular atrophy.

Schlokov in 1879 described a singular affection of the spinal cord among zinc smelters, characterised by disorders of sensation and paralysis; Murray in 1900 reported digestive disturbances and wasting among brass workers, and, similarly, McCord and Friedlaender in 1936 observed among zinc workers gastric and duodenal ulcerations which they attributed to the action of zinc. But all experts who of recent years have studied in a systematic way the health conditions of zinc workers, among others Tracinski, Lehmann, Wutzdorff, Sicard, Gilbert, Hayhurst and Ph. Drinker, are unanimously of the opinion, with regard to the isolated cases of poisoning ascribed to zinc in literature, in so far as their occupational origin can be proved, that they were due to the action of lead, arsenic and other substances which are found with zinc, its ores and its compounds, rather than to zinc itself.

Seifert in 1918 is the only one of the opinion that, in the clinical picture which he had described in 1897 under the name of "caehexia of zinc smelters", which showed itself by wasting, anaemia, digestive disorders, colics and chronic nephritis, these conditions are due not only to lead, but also to zinc.
He bases his opinion, as the other French authors who have been mentioned have done, chiefly on the presence of zinc, in addition to lead, in the urine of the patient.

But this finding is not sufficient proof, as the researches of Rost and Weitzel, Fairhall, Lutz, Ph. Drinker and their co-workers have shown. Zinc has been found regularly in the excretions and organs of man and animals, as well as in the urine of the patient. Some experiments carried out on pregnant or suckling white rats gave the same negative results and no injurious influence was noticed in their descendants.

_Generous ague_ must not be regarded as a special case of acute occupational poisoning by absorbed zinc, but as a consequence of a local caustic action of zinc oxide. Described for the first time by Thackrah in 1832 among brass-founders in Birmingham, under the name of "brassfounders' ague", it was studied from the clinical and etiological points of view by Blandet in 1845, and later by Greenhow in 1862, as a result of inhaling "fumes" of zinc oxide. This disease has since then been the object of numerous clinical researches, and later of experimental work.

While the application of zinc in various ways — by intratracheal instillation, subcutaneous injection of tartrate of zinc and soda, and the inhalation of fumes given off at the time of the combustion of chemically pure zinc — did not enable K. B. Lehmann to obtain in animals symptoms resembling founders' fever, this expert, however, caused typical attacks in persons who had voluntarily submitted to be experimented upon. Lehmann in this way proved for the first time that it is finely powdered zinc oxide, and not copper or unknown impurities in the brass, which cause founders' fever. In the same way as Lehmann, Rost also was able to cause in man, but not in animals, typical founders' fever, by using for inhalation the fumes given off in brass foundries. The inhalation of very concentrated fumes of zinc, 1.0 to 2.5 grm. per cm., causes in guinea-pigs a fall of temperature, followed by a rise reaching 3.3° C., with strong irritation of the respiratory organs and patches of broncho-pneumonia (Turner and Thompson, 1929).

The exclusive action exerted by zinc oxide on the respiratory passages is explained by Lehmann on the hypothesis that the immediate cause of the fever is not the absorption of the zinc oxide itself, but rather of albumen denatured or of a strange kind, arising either from destruction of the epithelium or from the destruction of micro-organisms in the respiratory passages. Schmidt Kehl in 1926, in
trying to confirm this generally accepted hypothesis by experimentation, was able to cause marked rises of temperature (0.5 to 1.6° C.) in guinea-pigs by injecting them, either subcutaneously or intravenously, with serum from their own species, which had been brought into contact by spraying into a chamber, with finely distributed fumes of zinc oxide.

In opposition to Lehmann and Rost, Kisskalt in 1912 and more recently Burstein in 1925 have been able to obtain rises of temperature in experimental animals by subcutaneous or intravenous injection of salts of zinc. Burstein, as a result of these experiments, maintains that zinc exerts an action on thermo-regulating centres by means of absorption; and Kisskalt, who has caused rises of temperature and conditions of irritation in the respiratory passages by causing mercury fumes to be inhaled, considers, on referring to symptoms of poisoning of a similar kind observed in cases of poisoning by the carbonyls of nickel and iron, that founders' ague is a phenomenon characteristic of the absorption of all heavy metals, and that the specific action of zinc is only due to the fact that it has a melting point which is very close to that of boiling. Symptoms similar to those of founders' ague were, as a matter of fact, observed by Hansen in 1911 and Koelsch in 1923, following the inhalation of copper fumes; by K. and Ph. Drinker in 1927-1928 who caused slight symptoms in man of founders' ague with a rise of temperature, and, experimentally, in animals, falls of temperature with fumes of magnesium, a light metal, chemically very akin to zinc. Hence the hypothesis of Kisskalt, speak of "metal fume fever".

It must be acknowledged that the possibility of founders' ague, caused by the vapoours and fumes of oxides of other metals, has only a theoretical importance for the expert in industrial hygiene. The question: "why typical founders' ague occurs only on the inhalation of zinc fumes in the nascent state and not after inhaling dust of zinc oxide, which is chemically identical," was taken up by Ph. Drinker in 1922; he emphasises the pathogenic importance of the degree of dispersion and the size of the particles of zinc oxide. Zinc fumes produced by the combustion of zinc are constituted by aerosols in a very fine state of dispersion. The effect of cooling and humidity on oxide of zinc is to separate it by flocculation in the form of a powder with coarse particles, which, even when inhaled, does not cause founders' ague. In support of this view, sometimes cases of ague are observed in zinc oxide works among men cleaning pipes not sufficiently cooled. But these attacks have never been observed in persons employed in filter chambers and in places where the product is barrelled, in spite of considerable liberation of dust. Ph. Drinker in 1927 reproduced in men the symptoms of founders' ague by making them inhale very fine zinc oxide powder (kadox) with particles 0.40 in diameter, dried for some time and pulverised at 110° C.

Burstein in 1925 also caused in three persons founders' ague by the inhalation of finely pulverised zinc oxide.

Mazzi in 1930 undertook an investigation into founders' ague; and has come to the conclusions: that the febrile attack must be assigned without any doubt to the inhalation of fumes of zinc oxide, suspended in the air of the foundries; that it cannot be interpreted as a manifestation of acute poisoning by zinc; that the pathogenic mechanism cannot be explained in a satisfactory way by the hypothesis of anaphylaxis, nor by that of disturbance of the basic acid equilibrium; and that, in the present state of knowledge, the febrile attack must probably be ascribed to the pathogenic action of zinc oxide on the extremely delicate epithelium lining the final ramifications of the air passages. The proteins, the entrance of which into the plasma, under this astringent and caustic action, appear to give rise to the formation of hetero- and meta-proteins, the entrance of which into the circulation seems to be capable, when in contact with the heat-regulating centres, of disturbing the equilibrium of these centres; in this way it is explained the heat-production reaction.

Mazzi, approaching the subject from the medico-legal point of view, does not consider founders' ague to be an accident, but as "an acute occupational disease", to be classified in what may be called a neutral zone, standing between an accident and an occupational disease properly so called. For this reason, he considers that it cannot be compensated either as an occupational disease or as an accident, but it falls within the list of ordinary health insurance diseases.

Data obtained from foundries provide information concerning the quantities of zinc oxide necessary for causing founders' ague. The ague has made its appearance when the content of zinc oxide in the air was 230 mg. per cm. according to Arnstein, and 124 to 420 mg. according to Lehmann. According to Arnstein, the amount of zinc oxide effectively inhaled could be
estimated, depending on the duration of work, at 6 to 790 mg.; according to Lehmann at 30 to 150; and, according to Burstein, at 1 mg. per kilogram of body weight. Ph. Drinker, Thompson and Finn established, by a series of experiments, a "threshold", for man of 15 mg. of zinc oxide, as fumes, per cm. of air, acting over several hours. They consider this limit as the maximum admissible from the hygienic point of view for a spell of work of eight hours. These experts, by taking into account their special investigations made in 1928, on the atomic volume and the quotient of absorption in the respiratory passages, which they found to be from 40 to 70 per cent, for zinc fumes and very fine zinc (kadox), estimate the quantity of zinc in the lungs at the time of the production of founders' ague to be 24-37 mg. In further researches in 1928 they found, in addition, that the quantity of zinc detected by analysis in the lungs only increased during the first forty-five minutes of inhalation, and that the strength of zinc in the lungs rapidly diminishes after inhalation, whilst that found in the liver and pancreas increases.

In practice, it was found that under some conditions a short inhalation of fumes during the melting of zinc, lasting only five minutes, but during which about 7 mg. of zinc oxide might be inhaled, was sufficient to cause a typical attack of founders' ague (Arnstein, Lehmann).

**STATISTICS**

Detailed statistics on the health conditions of zinc smelters at spelter works, especially taking into account the risk of lead poisoning, were drawn up in 1912 by the Prussian factory inspectors for twenty-three Silesian firms in the Oppeln district for the period 1902 to 1911. The enquiry deals on an average with 4,794 furnace workers, among whom are included men removing ashes and raking out broken fragments from muffles, while men who were employed in the manufacture of muffles and condensers, and in the transport of charcoal and ores are excluded, a total of 52,736 persons came under observation. According to this enquiry the following disease rates were observed:

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Total number during ten years (annual average 4,794)</th>
<th>Per 1,000 and per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>Days of sickness</td>
</tr>
<tr>
<td>Colic and lead paralysis</td>
<td>521</td>
<td>13,180</td>
</tr>
<tr>
<td>Nephritis</td>
<td>238</td>
<td>7,745</td>
</tr>
<tr>
<td>Gastro-intestinal catarrh</td>
<td>2,271</td>
<td>59,521</td>
</tr>
<tr>
<td>Anaemia</td>
<td>201</td>
<td>4,297</td>
</tr>
<tr>
<td>Rheumatism</td>
<td>6,507</td>
<td>107,663</td>
</tr>
</tbody>
</table>

The statistics for 1911 are more complete and more detailed: they deal with 4,894 workmen at spelter furnaces, and 1,466 at roasting or calcining furnaces. Among this personnel there were per 1,000 workmen:

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Furnaces for zinc (etc.)</th>
<th>Roasting furnaces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>Days of sickness</td>
</tr>
<tr>
<td>Colic and lead paralysis</td>
<td>42.3</td>
<td>176</td>
</tr>
<tr>
<td>Nephritis</td>
<td>2.6</td>
<td>56</td>
</tr>
<tr>
<td>Gastro-intestinal catarrh</td>
<td>44.3</td>
<td>684</td>
</tr>
<tr>
<td>Anaemia</td>
<td>2.8</td>
<td>78</td>
</tr>
<tr>
<td>Rheumatism</td>
<td>107.3</td>
<td>1,899</td>
</tr>
<tr>
<td>Respiratory diseases</td>
<td>38.4</td>
<td>833</td>
</tr>
<tr>
<td>Other diseases</td>
<td>130.3</td>
<td>1,794</td>
</tr>
<tr>
<td>Total sickness (excluding accidents)</td>
<td>356.7</td>
<td>5,443</td>
</tr>
</tbody>
</table>

A thorough medical examination of the furnace workers of the same firms, including those employed in the removal of ashes and the making of muffles, was ordered by the Prussian Minister of Commerce and Industry and carried out from 1909 to 1914 by Schweitzer, Wrobel and Halbey; and the results were published by the last named. Out of 6,150 workers in zinc foundries or spelter works in the Katowitz district, 2,155 persons, 156 of whom were women, were examined because they showed symptoms, or disturbed health, attributable to lead. Of this total, 1,888 were employed at spelter furnaces, and 297 at roasting and calcining.
Among the spelter furnace workers, a lead line and other signs of lead absorption were observed in the proportion of 14 to 66 per cent. of the total strength, and in the total of those examined at arsenic and lead smelting, the proportion was from 11 to 27 per cent., with an average of 24; among the workers employed on the calcining of foundries at about 15 per cent., with signs of lead poisoning in as many as 25 to 33 per cent. of all examined, which represents a surprising finding. One of the examiners found that red blood corpuscles with basophilic granulation were present, sometimes in as many as 91 per cent. of those examined at certain foundries; another found among many as 91 per cent. of those examined at certain foundries; another found among 512 smelters a blood pressure of more than 150 mm. of mercury in 28 per cent., which was not attributed to lead poisoning, but rather to such other causes as abuse of tobacco; typical chronic nephritis, with neuro-retinitis and albuminuria, was found in one case and lead paralysis in two cases. One of the examiners also found signs of mild anaemia, with diminution of haemoglobin, in 28.9 per cent., of those examined at about 26 per cent.; among the blende calciners the proportion was from 11 to 27 per cent., with an average of 24; among the workers employed on the calcining of foundries at about 15 per cent., with signs of lead poisoning in as many as 25 to 33 per cent. of all examined, which represents a surprising finding. One of the examiners found that red blood corpuscles with basophilic granulation were present, sometimes in as many as 91 per cent. of those examined at certain foundries; another found among many as 91 per cent. of those examined at certain foundries; another found among 512 smelters a blood pressure of more than 150 mm. of mercury in 28 per cent., which was not attributed to lead poisoning, but rather to such other causes as abuse of tobacco; typical chronic nephritis, with neuro-retinitis and albuminuria, was found in one case and lead paralysis in two cases. One of the examiners also found signs of mild anaemia, with diminution of haemoglobin, in 28.9 per cent. of the workers examined.

It is interesting to note that the investigation made by Batchelor and his colleagues in 1929, which was carried out at a spelter works in North America, where Franklinite, an ore free from lead, was used for the preparation of metallic zinc, and, especially, of zinc oxide, lithopone and zinc dust, did not reveal any pathological condition among the workmen, beyond slight changes in the lungs due to dust, revealed by X-rays; two cases of arterial hypertension in older individuals, and some isolated cases of slight leucocytosis. Analysis of urine and faeces of the workmen examined, disclosed the presence of quantities of zinc greatly exceeding the normal. The workmen in question were employed chiefly at the preparation and barrelling of zinc oxide.

The investigation of Lehmann in 1927 to 1928 on the state of health of German workmen who prepare zinc oxide by the direct process showed clearly that, out of 177 workmen belonging to various firms, 6 cases (3.4 per cent.) were affected with slight lead poisoning and 19 (11.3 per cent.), were regarded as "lead-poisoning suspects".

According to an investigation made by the Factory Inspection Department of Württemberg, the height of the workplaces plays an important part in the incidence of founders'ague. In works where the workplaces are from 8 to 12 m. high, some of which have artificial ventilation, there were only isolated cases of sickness; this sickness was more common in medium sized foundries with workplaces from 4 to 5 metres high, and occurred after almost every operation in works having only 2 to 4 metres of height.

An English investigation into founders'ague carried on from 1902 to 1909, dealt with twenty-one brass foundries in Birmingham employing 500 workmen, 233 of whom were founders, and with the Royal Arsenal with 58 founders; it disclosed that, out of 216 founders examined, 23 per cent. had definite indications of disorders due to foundry work. But more exact analyses showed that of 135 founders, 123 (86.6 per cent.) were affected with typical founders'ague, whilst among 58 workmen at the Arsenal employed in bronze foundry there were only 6 (about 10 per cent.) that were affected with the fever.

A further enquiry, made by Collis, for the English Factory Department, was published in 1910; it dealt with the smelting of materials containing lead and included the processes of zinc smelting. The chief cause of ill-health discussed is lead poisoning; out of 160 cases which occurred during five years, 1905 to 1909, in all lead smelting processes discussed, 73 occurred among spelter workers who were found to experience an undue amount of lost time for sickness and to remain an unusually short time in the industry.

In Belgium, during an enquiry in 1925 dealing with 325 workmen at zinc works, Gilbert found that 94.46 per cent. were in a good state of health; but 97 (29.84 per cent.) showed a lead line; 170 (53.31 per cent.) had red blood cells with basophilic granulations; and also the haemoglobin content was reduced, below 75 per cent. on the Tallquist scale, in 30 per cent. of all the workmen examined.

**SYMPTOMS**

Skin affections due to zinc and its compounds are not common. Oliver has observed ulcerations and pustules in men employed in handling non-calcined calamine; John A. Turner in 1921 described under the name of "oxide pox" a dermatitis among the workmen of a zinc oxide factory which he attributed to the ducts of the sebaceous glands becoming blocked by the dust of zinc oxide. Sweating, dirtiness and scratching, especially during the hot season, favoured the development of a papulo-pustulous exanthema (32 cases) in men in places where oxide was packed into barrels. The presence of arsenic even in traces, such as 50 mg. per 1,000, in zinc may explain the irritating effect on the skin. But other authorities (Lehmann) do not agree with this hypothesis.

The handling, in particular, of the chloride and other salts of zinc has a caustic effect on the skin, which is sometimes very serious. The use of chloride solution for soldering, as a mordant, as an application in the preliminary preparation of cloth and silk, and for dyeing, causes typical ulcerations, which were situated on the fingers, sometimes on the hands and forearms, and, more rarely, on other parts of the body. In 1921, Carey, McCord and Kikker described 17 cases of ulcers and acne situated on the fing-
ners, and less commonly on the forearms, the groins, the scrotum and the thighs, among men employed on impregnating wood, previously treated with tar and creosote, with a solution of zinc chloride. Nurnberg in 1922 reported violent inflammation of the throat accompanied by oedema in a carpenter who had worked on a copper galvanized iron treated with zinc chloride.

In Great Britain the Medical Inspector of Factories in 1925 recorded a form of dermatitis due to the action of the solution used for soldering; the eruptions only occurred in women who had burns or other eruptions on their arms and hands. The patients had tried to reduce the acidity of the solution, so as to render it less caustic; but the result was an increase in its irritating properties. Probably the irritation produced by a splash of the solution on a definite spot necessitated immediate washing of the part affected, whilst diminution in the acidity allowed more prolonged exposure leading to a more serious vesicant effect.

Orator in 1929 reported cases of corrosion of the mucous membrane of the stomach, following upon inhalation of the copper fumes and lesions to be due to zinc which had been swallowed and dissolved in the hydrochloric acid of the stomach; the resulting chloride of zinc would have a corrosive effect.

Except for founders' ague, occupational poisoning by zinc cannot be claimed to exist to-day. Zinc smelters' cachexia (Zinkhüttenstéchtum) so named by some German authors is, in its essential manifestations, only more or less typical chronic lead poisoning; for there is found the lead line, anaemia with red blood cells containing basophilic granulations, wasting, profuse sweating and marked pruritus; some hours later, arid, congestion of the face and injection of the conjunctivae; some hours later, and, in severe cases, only on the next day, the temperature falls by crisis, with profuse sweating and marked prostration. As a rule the patients are fit for work the following day. Recurrence of the disease on the following day is unusual.

Pulmonary and bronchitis symptoms may be very marked. Respiration is sometimes superficial and laboured. Associated, according to Ph. Drinker, with diminution in the vital capacity to as low as one-half; there is also a strong tendency to cough. The urine, during and after the attack, is diminished in quantity and is dense, but it rarely contains albumen (Sigel, K. C. Lehmann, Zadek). Guellmann in 1925 described some cases with glycosuria and intense hyperglycaemia (up to 0.199

Gilibert states: "Most workmen at zinc foundries or spelter works exhibit obvious signs of impregnation by lead; but it seems that the effect of this poison on their health is not generally so definite as to cause in many the classical manifestations of lead poisoning. Measures for health preservation are, however, necessary, and to regard for there is no doubt that the impregnation of lead which these men receive must have a bad effect on any tendency to sickness and on intercurrent diseases. As regards carbon monoxide, its effect seems clear; but it does not seem to exert a powerful effect on the health of the body."

The only ill-effects which can be attributed to zinc, viz, those due to founders' ague, show an extraordinarily typical clinical picture, which was well described by early observers, and completed recently by knowledge acquired regard the changes in the blood formula.

Some time after a somewhat prolonged stay in a brass foundry, possibly as long as eight hours, the workman is affected with a general malaise, which may supervene towards the end of the day's work, or, more often, during the following night. It is characterised by fatigue, extending to a feeling of prostration, yawning, pains in the limbs, cephalgia, shivering, sensation of dryness and tickling in the throat and trachea, and cough. In serious cases, there is next experienced violent shivering and a quick rise of temperature (up to 39-40° C.) with all the subjective symptoms of fever: pains in the limbs, headache, buzzing in the ears, nausea, vomiting and sometimes mental confusion, hallucinations and convulsions (Wilke, Guellmann). During the attack is congestion of the face and injection of the conjunctivae; some hours later, and, in severe cases, only on the next day, the temperature falls by crisis, with profuse sweating and marked prostration. As a rule the patients are fit for work the following day. Recurrence of the disease on the following day is unusual.
per cent.) which he interpreted as signs of disordered hepatic action. The same authority reported acute congestion of the liver, which is intense during an attack of fever, as well as chronic hypertrophy of the liver, in 3 brass founders who had had repeated attacks; and in the urine of some workmen, urobilin, haematorphyrin, and sometimes also even of indican. Lehmann has produced experimentally, in the urine, albumen, indican and hyaline casts.

With regard to the heart and blood vessels, in addition to acceleration of the pulse, a slight increase in the systolic and diastolic pressure is observed during the attack, whether febrile or not (Guelmann).

The blood formula shows a leucocytosis, especially of the neutrophiles with a polymorphic nucleus, amounting to 16,000 or 17,000 (Arnstein, Ph. Drinker and his colleagues); or a relative lymphocytosis up to 50 per cent., as well as a slight eosinophilia (disagreement with Arnstein!), and, in the brass workers examined, who had had several attacks of founders' ague, anaemia with marked oligochromaemia, accompanied in some cases by anisocytosis and poikilocytosis (Guelmann).

Although a cumulative effect of zinc cannot be demonstrated, attacks of founders' ague, often repeated, seem able to originate a general debility with anaemia and respiratory affections (Sigel), especially in the case of persons in whom there is disease of the circulatory system.

Whilst a single attack of fever is generally quite harmless and terminates with complete recovery, Graeve in 1907 described a case in which he was able to establish the relation of cause and effect between the onset of the fever and death which occurred later. It was the case of a workman who had a febrile attack during melting of zinc residue; he died a week later from acute oedema of the brain. Graeve has also described a swelling of the spleen and a certain swelling of the intestinal haemorrhage following a severe attack of founders' ague.

Some authors (Rost) regard an attack of founders' ague as typical only if it is accompanied by a rise of temperature. However, it is certain that slight, afebrile attacks, with marked subjective disorders, occur even more often than typical serious attacks. In these cases the symptoms resemble a commencing chill and are so characteristic that a diagnosis of founders' ague can be made with certainty; moreover, leucocytosis is present.

The liability to contract the fever certainly varies a good deal in different workmen.

Persons who have recently commenced work, or whose work in foundries has been interrupted for some time are more often affected than others; this points to the establishment of an immunity. It is not certain whether this can result in complete immunity or only cause a reduction in the severity of the attack, which is accepted by many workmen as something inevitable. However that may be, a serious attack is followed by increased resistance for some days, which may also be demonstrated by experimental methods (Ph. Drinker). On the other hand, it is proved that even elderly workmen may have attacks at close intervals. Thus, Sigel mentions the case of a founder, aged fifty-eight years, in whom he observed a whole series of sharp attacks with all the characteristic symptoms, occurring with intervals of two to three days. Several authors (Lewin, Roth, Arnstein), consider that only a minority of founders exhibit a natural immunity. But there is no definite proof to support this view.

In Great Britain, the Medical Inspector of Factories reported in 1927 three cases of toxic jaundice which occurred in making zinc salts, and were due to the inhalation of sulphuretted hydrogen. The affected workmen were employed in guiding loads of zinc into chutes leading to dissolving tanks.

**DETECTION**

Compounds of zinc moistened with a solution of cobalt salts give, when melted on charcoal with the blowpipe, a beautiful green head ("green cinnabar").

Zinc sulphide, or zinc white, is insoluble in acetic acid and soluble in mineral acids; it is precipitated by ammonium sulphone.

In order to detect metallic zinc powder in zinc oxide, Lehmann recommends treatment with mineral acids, in the presence of a little platinum chloride, when the evolution of hydrogen indicates the presence of metallic zinc.

Qualitative and quantitative estimation in such organic secretions and excretions as urine and faeces, etc. Inocerate the organic material by either a dry or moist method; take up the residue with 250 cub. cm. of dilute hydrochloric acid and saturate the filtered hydrochloric solution with sulphuretted hydrogen in order to eliminate copper, etc.; filter the solution and wash with water containing sulphuretted hydrogen. Remove the sulphuretted hydrogen from the filtrate and the washing water, by boiling and heating with hydro-
chloric acid; after cooling, render alkaline with hydrate of soda of a strength of 30 per cent., then render slightly acid with acetic acid and filter, after the precipitate has deposited. Take the residue from filtering again with dilute hydrochloric acid and treat the hydrochloric solution with hydrate of soda and acetic acid. Collect the filtrates, acidulate with acetic acid, and saturate with for three hours with sulphuretted hydrogen. Incinerate and calcine, with the filter paper, the zinc sulphide which has been precipitated and filtered, after washing with water containing sulphuretted hydrogen. Remove all trace of iron by dissolving repeatedly in 2 per cent. acetic acid; filter and precipitate with sulphuretted hydrogen. Separate the precipitated zinc sulphide, calcine it in a quartz crucible, and weigh it as zinc oxide.

For the detection of very small quantities of zinc, dissolve the precipitate of zinc sulphide in dilute boiling hydrochloric acid; neutralise with ammonia so that the reaction is very feebly acid; titrate by the volumetric method, using a solution of potassium ferrocyanide of a special strength (according to Fahlberg), and using uranium acetate as an indicator.

For the estimation of very small quantities (0.01 to 0.5 mg.) in organic products, R. E. Lutz in 1925 published a very sensitive colorimetric method, based on the fluorescence of zinc salts with urobinil. It requires very exact and delicate precautions during the incineration and analytical isolation of the zinc, for it only gives sufficiently accurate results with very pure solutions of zinc salt.

**HYGIENE**

In spelter works or zinc-smelting factories, hygiene demands the application of preventive measures for reducing or eliminating the effect of radiant heat and high temperatures of the air, in order to suppress, as far as possible, dust and gases arising from the roasting furnaces and from the retorts for distillation, and to reduce the physical effort required of the workers. Measures for removing dust must be adopted particularly in workplaces during operations in which dust containing lead may be given off. Spacious buildings of high construction must be provided for the roasting or calcining furnaces, and the retort house for distillation. Natural ventilation should be ensured by constructing numerous windows in the walls and ventilating shafts in the roof; in this way the hot air can be removed without having recourse to artificial ventilation. On the other hand, care must be taken to avoid any risk of chilling the workers by exaggerated ventilation, by using windows supplied as far as possible with louvres, and by regulating the closing of the opposite rows of openings. In order to reduce the trouble caused by radiant heat, free space is needed before and below the openings for tending the furnaces. A distance of at least 6 metres should be arranged between the wall of the retort house and the furnace, or about 12 metres, if the faces of the furnaces are opposite one another. The furnaces must be arranged in a single row when the buildings are comparatively narrow; in this way normally adequate ventilation can be assured. In large buildings with several rows of furnaces, natural ventilation is insufficient; it must be improved by blowing in fresh air, as in glass works, on to the working places in front of the furnaces.

The walls must be smooth; and the floor must have an even surface, so as to avoid any deposit of dust and facilitate cleaning.

The escape of such gases as sulphur dioxide from the roasting furnaces must be prevented by arranging efficient exhaust ventilation above the openings for charging and tending the furnaces.

The introduction of labour-saving devices, which were introduced originally for purely economic and technical considerations, has led to notable hygienic improvement. By this means, at the outset, hand shovelling was abolished; this required of the men employed on roasting very great physical exertion and exposed them to the ill-effects of heat, dust and gases from the furnaces. Further progress has been made by replacing the old furnaces by muffie furnaces of various types with continuous charging and mechanical transport for calcined ores. At the present time, complete desulphuration of the ore can be easily attained, whilst the gases are used to make sulphuric acid or liquid sulphurous acid. By these means a satisfactory solution has been arrived at, equally from the technical and economical point of view as from that of health, of a problem which up till recently offered difficulty with the old furnaces, viz. that of removing the sulphur fumes and avoiding sources of trouble for the workers and for the neighbourhood. The gases are conducted by a powerful exhaust directly towards a sulphuric acid plant. The roasting or calcining furnaces are in this way kept continually under negative pressure, so that the gases given off are entirely prevented from escaping and polluting the vicinity.

In smelting works where furnaces of the old type are still used, the sulphur
gas is not used, but is eliminated by milk of lime in special towers. However, the high temperature of the gases from roasting does not make it possible to obtain a complete reaction, Hence, the absorption method is replaced by diluting the gases and using a forced draft, which carries them into the air as high as possible. But this procedure is not efficient either, for the gases and the fumes have a tendency to flocculate and precipitate on the ground in the vicinity of the procedure placed by diluting the gases and using sensible be drawn towards intake ducts situated above the condensers from which an air current can be arranged over the openings of the con-

Lead, beginning of carbon and which are liberated during distillation type of furnace it should be said that the use of this which use large Silesian muffles. This to be neglected in smelting works.

The ashes rich in lead which, when the muffles are drawn, are still hot and giving off gases and dust, should never be drawn on to the floor of the foundry, but collected into special shoots, from which they pass directly after complete cooling into small trucks. Quenching or moistening of ashes which are not cooled must be avoided, for there may be danger from the evolution of explosive or toxic gases such as arseniuretted hydrogen.

The collection and further handling of dust calls for the adoption of special measures, particularly on account of the risk of lead poisoning. Sifting and packing into barrels must be done in special places and in closed apparatus, in order to avoid raising dust.

When the plant handles ores containing lead, in addition to the above-mentioned technical measures, all those relating to personal hygiene laid down for works where there is a risk of lead poisoning must be applied, e.g. the use of working clothes, and the provision of lavatories and haths, cloakrooms and canteens. Where in certain workshops there may exist an increased risk of lead poisoning, a medical examination of the personnel on entering the factory and periodically thereafter, must be arranged. Youths and women must not be employed at the roasting furnaces, the distillation retorts, or at the removal of dross.

In brassfoundries good general ventilation of workplaces is needed, with exhaust hoods above the working posts, to remove the zinc fumes given off at the time of pouring. This local exhaust may have to be arranged under difficulties, especially if pouring into mobile moulds is being carried on in several places; but, recourse can then be had to movable exhaust hoods. Lehmann has described an arrangement adopted in a German foundry which has ceased using mobile crucibles, and prefers to move the moulds one after the other towards the crucibles placed under a strong exhaust ventilation. As the technical equipment in older works does not always give a guarantee for efficiency, recourse must be had to the wearing of respirators during pouring. However, the models with a simple cotton filter or a damp sponge are ineffective.
and it is necessary to use masks with a colloidal filter which completely absorbs metallic fumes.

**LEGISLATION**

Boys under sixteen years are excluded from the work of cleaning zinc with acids in Canada (Quebec); in zinc oxide works women are excluded in Argentina and the Netherlands; young persons under sixteen years, in Belgium; under eighteen years, in France from workshops for combustion and condensation; under seventeen years, in Belgium, under eighteen years, in Argentina, from factories for the manufacturing of zinc oxide as well as its manipulation with the object of preparing it for sale, in the Netherlands. Boys under fifteen years and women under twenty-one are excluded from zinc oxide works; etc.

In Norway pregnant women and young persons under eighteen years are excluded from works where toxic materials are used, and works where the hydrated carbonate of zinc is made; young persons under sixteen years are excluded from sulphate of zinc works, in Belgium.

Special legislation exists in Germany where a Federal Ordinance of 6 February 1900 deals with the erection and running of zinc melts. It prescribes: minimal conditions from the point of view of construction; the installation and supply of drinking water; the separation of roasting and calcining sections from those for distillation; the use of closed apparatus for the crushing of ores; the provision of exhaust ventilation at the furnaces for roasting, calcining and distillation; it also recommends that the raising of dust during the loading of the furnaces should be prevented by humidification applied to the reducing mixture, as well as during drawing and the removal of dress; the use of closed separators for sifting and packing powdered zinc into barrels; limitation of the employment of women and young persons; the provision for the workers of lavatories, baths, cloak-rooms and canteens; medical supervision of workers by periodical medical examination where cases of lead poisoning occur.

Special permission is required for the erection of new distillation furnaces both as regards construction and arrangement.

In Austria, the Ordinance of 22 July 1908, issued by the Ministers of Public Works and of the Interior, regulates the erection and running of lead and zinc-smelting works established in conformity with the general law on mines. A circular dated 10 August 1910 on lead poisoning among workmen at zinc and lead smelting works contains the text of "warning notices" to be distributed to workers.

More recently, 8 March 1924, four Ordinances of the Federal Ministry of Social Administration issued in agreement with the Ministries of Commerce, Industry and Public Works, lay down regulations for the protection of the lives and health of persons employed in lead and zinc smelting works and in zinc white works, under the regulations of the Industrial Code.

In Belgium, the Royal Order of 12 March and 8 July 1925 regulating zinc works, lays down the measures imposed on employers and workmen regarding health supervision and medical service; in Great Britain, hygienic provisions relating to brassfoundries are contained in the regulations of 30 June 1908; the Regulations governing the smoking of materials containing lead include the smoking of zinc ores, and are dated 12 August 1911; and for Norway, the industry is controlled by the Ordinance of 30 October 1919.

Notification of cases of poisoning by zinc and its compounds is provided for in Poland (Ministerial Order of 30 October 1920); and in the Netherlands, of cases occurring in "yellow copper" foundries and soldering workshops (zinc oxide).

Compensation is granted in Belgium, Bulgaria, Cuba, Hungary, Ireland, Latvia, Luxemburg, Netherlands and Portugal, by national laws ratifying the Convention of 1925 relating to lead poisoning due to use of lead, its alloys and compounds; handling of ore containing lead fine shot in zinc factories; in Italy, and in the United States (Illinois and New York) during use of zinc, its alloys and compounds; in Missouri, Ohio and Porto Rico, for disease due to refining and melting of zinc; in Queensland and Chile, in Switzerland, for effects due to zinc chloride; in U.S.S.R. for lead poisoning. Dermatitis from chloride of zinc is compensated in Bulgaria and in the U.S.S.R.

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ZINC


Dr. H. Engel
(Berlin).

"No man's work should be a danger to his health or a menace to his life."

(From the Prince of Wales's speech to the annual meeting of the Industrial Health Education Society, London, April 1931.)
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ERRATA AND ADDENDA

Volume I

List of Articles in Volume II, p. xxvi: Between "Shoddy" and "Silk" read "Silicon"; between "Talc" and "Taxidermists" read "Tantalum".

List of Collaborators, p. xxi: Between "MYERS" and "OBLATH" read "NAESLUND, Dr. C., Assistant Professor at the Faculty of Medicine, University of Upsala, Sweden."

Opposite "SCHMIDT": "Medical Clinic" should read "Hygiene Institute".

ANTHRAX, p. 145, col. 2, sub-title (Spanish): "Pustala" should read "Pustula".

ARTIFICIAL SILK, p. 184, col. 1, par. 3: Delete this paragraph and insert the following text:

"In the rubber industry cases of chronic poisoning have been met with, but the symptoms were not serious.

"Amongst the most recent cases may be mentioned one by Boveri in 1929 affecting a worker in the artificial silk industry who suffered from serious glomerulo-nephritis; 2 cases reported in 1930 by Mauro amongst workers engaged in the preparation of an insecticide powder with a basis of potash soap, phenol and carbon tetrachloride; and 8 cases, one of which was fatal, studied in 1931 by Tovo and due to the breakage of a receptacle containing carbon tetrachloride."

p. 372, col. 1, "Symptoms": Add the two following paragraphs to the text:

"MacCord classified injuries produced as local injuries (dermatitis), acute poisoning (inflammation of the eyes and the respiratory passages), chronic poisoning, characterised especially by degeneration of liver and kidneys.

"In recent years Boveri (1929), Mauro (1930), Tovo, Nebuloni (1931) have drawn attention to kidney troubles said to be more frequent than had been imagined (7 of the 8 cases mentioned by Tovo and the fatal case which was due to an attack of uraemia) and which are characterised chiefly by oliguria, anuria, albuminuria, and granular and hyalin casts in the sediments. Mauro has likewise noted cutaneous irritation of the hands amongst workers coming into contact with tetrachloride."

COAL TAR, p. 470, col. 2, line 6: After "distilleries" add: "and from manufacturing tar oils in general".

DIVERS, p. 586, col. 1, par. 4: "Zenos" should read "Zervos", "1904", "1903".

ETHYLENE, p. 696, col. 1, par. 1: Figures in table should read as follows:

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FOOD OF THE INDUSTRIAL WORKER, p. 796, col. 2, last par., line 5: Add "per person per diem".
Food of the Industrial Worker, p. 797, col. 1, first table: Last figure under "Calories" should read "2,764.3".

—— p. 797, col. 1, par. 1, line 3: Add "and per 100 calories".

Gold Mines, p. 914: Insert before last paragraph:
"Compensation for miners' phthisis in South Africa was extended in 1926 to cover bricklayers and stonemasons who generally work at the surface of the mine, but whose duties take them underground periodically."

Hemp Manufacture, p. 940, col. 1, par. 1, line 6: Put full stop after "family", delete rest of paragraph and replace by:
"The principal commercial substitutes for real hemp (Cannabis sativa) are: Manila from Musa textilis, Henequen or Yucatan Sisal, from American Agaves, Sisal from Agave sisalana, Sunn hemp from Crotalaria juncea, New Zealand hemp from Phormium tenax. Aquatic hemp, Japanese hemp, African hemp and Indian ("Aloes") are of much less importance."

Volume II

Laundries, p. 98, Bibliography, line 6: "OLIVIER" should read "OLIVER".

Methyl Bromide, p. 238, col. 1, sub-title: "Monobromo Methane" should read "Monobromomethane".

Social Welfare, p. 906, col. 2, Bibliography: Add: