War and Industrial Diseases

by

Dr. Ludwig TELEKY (1)

GENERAL REMARKS

With the exception of acute infectious illnesses, no class of diseases varies so much in nature and extent as industrial diseases. These variations are due to changes in technical methods and in labour conditions. Thus "factory leg" disappeared when the shortening of hours of work and the improved protection of young persons prevented the latter from being exposed to unduly prolonged strain on the legs. This disease still persisted, however, in the form of "bakers' leg", until progressive measures for the protection of workers diminished the excessive hours of bakers' apprentices. During the war it re-appeared owing to the weakening of the bones of young persons by rickets caused by under-feeding. Mercury poisoning ceased to exist in the mirror industry when mirrors were made with silver instead of with mercury; and the Bavarian medical officer for industrial diseases, whose district had in previous decades been the centre of the mirror industry in Central Europe, had no opportunity of making a close study of mercury poisoning until mercury again began to be used in war industries. Thirty years ago, when the great chemical industry of Germany was being built up, "anilism" made its appearance. This was the name given to all poisoning caused by benzol and benzol derivatives. We now know and distinguish between the kinds of poisoning caused by each individual derivative of benzol, and are also well aware of a number of other causes of poisoning which have their origin in the development of the chemical industry. In the carrying on of war industries many victims were poisoned by substances which were unknown a few years ago and which even today are known by name only to a few medical men.

But the development and decay of great industries is not the only factor which can bring considerable changes in the nature and frequency of industrial diseases. Fashion also has its victims. The "fashion for white" (*weisse Mode*) in

(1) Formerly lecturer at the University of Vienna on industrial diseases and Austrian delegate to the conferences of the International Association for Labour Legislation; Director of the Institute of Social Hygiene, Düsseldorf.

painting and enamelling caused many cases of lead poisoning, as Sternberg of Vienna was one of the first to point out.

Alterations, experiments, and innovations in technical processes may eliminate some causes of industrial poisoning, or, on the contrary, may create hazards from new poisons. Two examples will show how slight are the differences which are sometimes in question, and how difficult it is for the student of industrial hygiene to discover them. In a certain factory, which manufactured caps for bottles, for years a large number of cases of lead poisoning used to occur. Since lead poisoning did not occur in other similar factories, the employer was inclined to regard the cases of lead poisoning in his works as a malicious invention of the doctors. The greater prevalence of lead poisoning in this factory, as compared with other factories, was found to be due simply to the fact that in this factory the layer of tin, covering the lead of the caps, was extremely thin. This thin layer was sometimes rubbed through in the processes of manufacture and the lead exposed. This caused cases of poisoning, which did not occur in other factories where the layer of tin was only imperceptibly thicker.

Again, many students of industrial hygiene have observed that chimney sweeps' cancer is more common in England than on the continent, and that diseases caused by pitch and tar are more frequent and more serious in that country (2). It has often been pointed out that differences in the composition of soot, pitch, and tar must here be of importance (3). English investigators have now discovered that tar and pitch obtained from gas works more frequently cause carcinoma than tar and pitch obtained from blast furnaces. This is not the result of different methods of manufacture, but simply of the fact that tar obtained from blast furnaces comes from Scotch slaty coal, while gas works now use only soft bituminous coal; English investigators (4) believe that they now have experimental proof, showing that this bituminous coal alone contains the irritant substances causing cancer. The frequency of chimney-sweeps' cancer and tar cancer will therefore fluctuate with the use of this type of coal. The effects of the peculiar character of English coal tar will be further discussed below.

The nature and extent of industrial diseases were profoundly and obviously influenced by the war and by accompanying economic disturbances. This article is concerned solely with industrial disease strictly so-called; it does not propose to deal with changes in the health of the population or of industrial sections of the population caused by the war, in

(2) LEYMANN, *Zentralblatt f. Gewerbehygiene*, 1913: ARNSTEIN, *Wiener Arbeiten aus d. Gebiet d. sozial. Medizin*, II, 11. 1912.
(3) KOELSCH.
(4) ROSS and CROPPER, *British Medical Journal*, 1913, p. 511.

spite of the fact that these were in themselves much more important.

The information on which this article is based was drawn from factory inspectors' reports in Germany, Austria, the United Kingdom, the Netherlands, and Switzerland, both from originals and, in the case of those passages which refer to industrial diseases, from translations made by Brezina with my assistance (5). I have also consulted published German literature (6) on industrial diseases, the publications of the British Ministry of Munitions and a few other British works, as well as Dutch and a few Italian publications. British periodical literature is not yet obtainable in Vienna, and it was also impossible to obtain French factory inspectors' reports, even through the French Embassy. I am not aware whether any such reports have been published since the beginning of the war (7).

This article will in the first place discuss industrial diseases which were common even before the war. Many of these diseases have decreased in extent, either because certain industries were brought to a standstill, or because materials were requisitioned for war purposes. Others have grown in extent, because certain substances were increasingly used during the war as substitutes for other more harmless materials. In the second place, I propose to discuss those types of industrial poisoning, which, although known and recognised before the war, have since received an enormously widened extension as war industry diseases or munitions manufacture diseases.

Metal Poisonings

Plumbism

I propose first to discuss the disease of plumbism. Before the war the incidence of this disease was not only greater than that of any other industrial disease, but it was actually more wide-spread than all other industrial diseases taken together.

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(5) This work is appearing shortly under the title *Internationale Uebersicht über Gewerbekrankheiten, nach den Berichten der Gewerbeinspektoren der Kulturländer 1914-1918 International Survey of Industrial Diseases based on Reports of Factory Inspectors in leading Countries, 1914-1918; in Schriften aus dem Gesamtgebiet der Gewerbehygiene,* published by the Institute for Industrial Hygiene in Frankfurt/a/M. (Springer); the *Survey* for the year 1913 is published by the same house. The 1914 *Survey* includes a quantity of detailed information from the inspectors' reports, to which only brief reference can be made here.

(6) The German authors mentioned in this article have for the most part published their work in the *Zentralblatt f. Gewerbehygiene;* see this publication *passim.*

(7) A report was recently published by the French Government, after the present article was sent to press. (Ed. *Inter. Lab. Rev.*)

In German lead works, output fell during the war, as many of these works had been working imported ores, at least in part. Thus in one German lead works, production was only a third of the pre-war amount, while another closed down entirely. Consequently, the number of cases of lead poisoning reported greatly decreased. There were fewer cases even where production did not decrease; this is attributed to the introduction of fresh workers as a result of mobilisation. Quite a different state of affairs prevailed in England, where lead works were working at high pressure. Here the number of cases of lead poisoning in 1915 to 1917 was above the average of the years immediately preceding the war.

In all countries lead was subject to Government control. It was extensively used in the manufacture of shells ; also in the chemical industry for the manufacture of vessels and containers for certain acids, etc.; here cases of lead poisoning occurred. The very extensive use of lead for shell manufacture, however, caused very few cases of poisoning. One reason was that metallic lead is less soluble even in the human organism than lead compounds. A second reason was one which is coming to be realised more and more clearly, namely, that the principal cause of poisoning is the breathing in of dust (lead dust, and to an even greater extent, dust of lead compounds) and lead vapour. When little dust or vapour is produced in the handling of the material, the danger is very slight. As lead becomes liquid at 360° C. (680° Fahr.), but does not vapourise till 550° C. (1022° Fahr.), it is comprehensible that, though there is a certain danger in the manufacture of the lead portions of shells, this is not so great as, for example, in the rubbing of lead paint or in other processes. Thus very few cases of lead poisoning were reported in shell manufacture; in Bavaria there was one case in the manufacture of infantry munition and in the whole of England only ten cases.

British reports state that the manufacture of lead containers for acids, of lead vessels, etc., gave rise to cases of plumbism. In 1915 there was a considerable increase in the number of cases of lead poisoning in the manufacture of accumulators (64 as compared with an average of 41 for the preceding years), the construction of submarines necessitating intensive work in this industry. (The same thing was reported from individual German factories.) The increase of plumbism in these branches of industry, however, bears no comparison with the decrease in other industries. The requisitioning of lead for military purposes naturally cut down the use of these substances for civil purposes, in particular for the manufacture of white lead paints, (in Germany also of red lead paints); in course of time it practically ceased. Lead poisoning in white lead factories, therefore, became less both in England and on the continent. Reports from the Düsseldorf district state that almost no white lead factories were running; in Hessen, where

there had been 125 certain, and 45 probable, cases of plumbism in 1913, they entirely closed down, and no cases were reported for the years 1916 to 1910. In England they were closed down for six months in 1917; in 1918 they produced 60 per cent. of peace-time requirements. In this industry there had been 399 cases of lead poisoning in 1899, but this had been reduced by hygienic measures to an average of 27 per year in 1912 to 1914. In 1915 the number rose to 40, but fell to zero in 1918, and rose again to 10 in 1919. The 1918 figure is probably principally due to the cessation of work in 1917, for lead workers of long standing had time in this enforced period of rest to get the lead out of their systems and become cured; when, on the other hand, the work was taken up again, the new workers did not fall ill until they had been at work for a certain time. Nevertheless, the production of red lead in England (in contrast to Germany) gave rise to more cases of poisoning in 1915 to 1917 than in previous years. This was probably due to the great demand for steel work and shipbuilding, not only for the British fleet, but for the fleets of the Allies.

The war influenced the actual use of lead paints and lead compounds even more than their manufacture. In Germany the house-painting industry, as indeed the whole building industry, entirely ceased work during the war. When painting was undertaken, e.g. in the case of steel-construction work (though there was very little of this), we learn from the report of the Potsdam district that iron oxide and micaceous paints were used, and have become so general that in future it is to be hoped leadless paints will be used altogether. The great Velten industry of glazed stove tiles was almost completely at a standstill. In England there was a considerable decrease in the manufacture of porcelain and earthenware. The number of cases of lead poisoning in this industry sank from a pre-war average of 56 to 11 in 1918, but rose again slightly in 1919 to 21. In other industries which make use of lead paints (colour works, shipbuilding, coach building) there were also far fewer cases of lead poisoning, partly because industry was restricted, and partly also because there was great shortage of material; for England had to produce lead paints and lead products not only for herself, but also for France and the other Allies.

In Germany it is obvious that the shortage of all lead-containing substances and still more the general shutting down of industrial activity were bound to lead to a general decrease in the number of cases of lead poisoning. in industries other than those to which reference has already been made. In 1913, for instance, 88 cases of lead poisoning were reported from Chemnitz; but the whole of the war period only produced 66 cases, while for each of the last two years the number was three only. In Leipzig there were 861 cases of lead poisoning in the last five years of peace, but only 161 cases in the years 1914 to 1916. The Leipzig inspector's very correct

description is "a welcome result of a less welcome cause". In a previous article (8) I have already shown how rare lead poisoning had become in Austria. I will merely mention here that the Federation of Trade Union Sick Funds and the General Fund for the Support of Workers and the Sick in Vienna, while reporting 188 cases of poisoning by mineral substances (i.e. principally lead poisoning) in 1911, reported only 99 cases in 1918. In Switzerland, too, there was a great decrease in the number of cases of lead poisoning. It is true that the shortage of cleansing materials, above all of soap, was favourable to the occurrence of lead poisoning, as many German factory inspectors state ; but this factor is almost negligible in comparison with the immense decrease in the danger of lead poisoning caused by the shutting down of works and by other causes which have already been described.

To sum up : while general slackness in business played a chief part in the decrease of lead poisoning in Germany and Austria, another essential factor was the smaller production and more infrequent use of lead compounds. In England this second factor was the decisive one. Lead compounds are in themselves much more dangerous to health than metallic lead, and their use causes poisoning with much greater frequency ; but, as I have already stated, it was rather metallic lead which was being increasingly manufactured and used in England. The number of cases of lead poisoning reported by doctors in England was on an average 522 in the years 1912 to 1914. In 1915 it was 381, in 1916 it sank to 348, in 1917 to 317, in 1918 to 148, and rose again in 1919 to 207.

In considering these figures, as well as those quoted elsewhere in this article, it must be remembered that in all belligerent countries war led to a slackening of regulations designed to protect the worker. The remodelling of peace industries to adapt them to war purposes and the rapid setting up of new industrial enterprises often involved, to a greater or less degree, neglect of necessary protective measures; only gradually were the authorities able to introduce necessary hygienic measures into the newly-constituted war industries. Later, towards the end of the war, shortage of labour and material made it impossible, above all in Germany, to set up new apparatus for the removal of dust and for ventilation purposes, or even to make the necessary repairs in existing installations. Again, it must be remembered, in considering the figures of the factory inspectors' reports, that these inspectors were overwhelmed with other work and that doctors were overworked, because so many of the medical profession had been called up. This led to lax notification of poisoning cases. I do not, however, myself attribute great importance to this as an explanation of the enormous decrease mentioned in all reports.

(8) *Wiener Klinische Wochenschrift*, 1920, No. 20.

It is worth adding that a British factory inspector (Shufflebotham) reported 14 cases of lead poisoning observed in soldiers. Their symptoms appeared three to seven weeks after they were mobilised, and their illness was probably to be attributed to the complete change which took place in their habits of life. Similar belated appearances of lead poisoning symptoms have also occasionally been observed in peace time.

Mercury Poisoning

During the war mercury was used in the Central European States for alloys which had previously been made with tin; this was done when sufficient quantities were available. Thus anti-friction alloys containing mercury were produced in the Magdeburg district, and in Munich a solder containing mercury (Rauhlot) was used instead of the usual tin solder, and led to slight cases of poisoning. A few cases were also observed in Vienna (9). The Prussian Minister of Commerce found it necessary to issue a warning against this kind of solder as late as September 1919. Koelsch reports more than 116 cases of mercury poisoning in a chemical works preparing mercury and oxide of mercury. It must be added that sublimate was so easy to obtain in military hospitals that it was frequently used for suicide or attempted suicide.

As fulminate of mercury is largely used in the manufacture of percussion caps, we should expect to find many cases of mercury poisoning in munitions works, both in the manufacture of the fulminate itself and in its use for percussion caps. Yet most investigators, e.g. Koelsch and Fischer of Potsdam, state that mercury poisoning did not occur in such industries, and that, if the factories were well equipped, there was no danger. From the Merseburg district, however, there are reports of "comparatively frequent cases of inflammation of the gums", and from Düsseldorf we hear of inflammation of the mucous membrane of the mouth with ulcers. Cases of stomatitis were also observed in Vienna (10), and typical cases of mercury poisoning occurred in England in the production and use of mercury fulminate. The number of such cases of mercury poisoning was on the whole very small. But there were a very large number of cases of other injuries traceable to fulminate of mercury: blackening and brittleness of the teeth, which must be considered an effect of fulminic acid (HO-N-C); irritation of the conjunctiva and of the mucous membrane of the upper bronchial passages, and, above all, exanthema and erythema. These symptoms had already been described before the war by German, French, and British writers, e.g. by Roth, Josias, and Legge; since

(9) STERNBERG. *Wiener Klinische Wochenschrift*, 1918, p. 141.
(10) OPPENHEIM. *Wiener Klinische Wochenschrift*, 1915, p. 1273.

then their frequent appearance has been described by a number of observers. A very large number of workers in German and Austrian factories, who worked on fulminate of mercury or fulminate salts, suffered from these disorders, some on the very day they began work, and others only during the hot weather. Numerous cases of exanthema attributable to the same cause are also reported from England: 345 during the first six months of 1916 and 232 during the first six months of 1917. Similar reports have also been received from America. It is difficult to prevent poisoning of this kind, because, as English reports state, the dust is so explosive that it cannot be drawn off in the usual way. When fulminate of mercury explodes, mercury vapour is produced, and although explosions of this kind are very frequent in the loading and compressing rooms, the quantities are too small, as Koelsch states, to produce illness in the large and airy rooms, which are generally well ventilated. I should, however, add for my part, that possibly the duration of the work was too short to give rise to symptoms of absolutely chronic mercury poisoning, and that it is most probable that, if the work were to continue for many years, even these very small quantities of mercury vapour, in combination with the dust of fulminate, would lead to certain symptoms of chronic mercury poisoning, such as tremor. Even during the war cases of mercury poisoning were observed, where these vapours were present in large quantities.

In an infantry munitions unloading factory Koelsch observed that all the thirty workers who were employed were suffering from stomatitis and some also from nervous irritability. Similar reports have also been received from other districts of Germany, such as Erfurt.

Arsenic Poisoning

Two forms of the effects of arsenic poisoning have been observed: the effect of arsenates, especially on the skin, and poisoning by arseniuretted hydrogen. A large increase in the number of cases of the first kind is reported from arsenic works in the Breslau district.

	No. of insured persons	Cases of arsenic poisoning
1913	107	7
1915	64	25
1917	137	111
1918	148	56

In most cases the skin and mucous membrane were affected by the corrosive action of acids containing arsenic, which also caused bronchial catarrh and perforation of the septum of the

nose. The increase in the number of cases was due to more extensive manufacture and to the employment of unskilled workers who had not yet learned caution; also to the fact that during the last two years of the war the workers were almost entirely without good underclothing. In addition, cases of arsenic poisoning occurred in the manufacture of smoke-developers, owing to the frequent fires. Similar effects were observed in works where fine powdered metallic arsenic was used. In England the production of bi-chloride of arsenic led to many cases of severe skin irritation. One case ended fatally owing to the absorption of arsenic through the skin.

The great development of the dye industry in England, as a result of the cutting off of German dyes, led to the frequent occurrence of poisoning by arsenuretted hydrogen; there were a large number of severe cases, some of which ended fatally. Many mild cases were observed in submarine crews; these were the result of the production of arsenuretted hydrogen by the accumulators of the submarines. It was at first thought that these cases were the result of the arsenic in the sulphuric acid; during the next trip arsenic-free acid was used. The cases, however, continued, and it was then discovered that the metal plates of the accumulators contained 0.2 per cent. of arsenic. These accumulators had been manufactured in 1911 and up till that time no cases of poisoning had been observed. It had not, however, previously been necessary to remain under water for so many hours. All the batteries of this class of submarines were then changed.

Between 1912 and 1914 there were, on an average, only four cases of industrial arsenical poisoning per year in England; in 1917 there were 30, of which five ended fatally. In Germany the war does not seem to have produced any large increase in the frequency of poisoning by arsenuretted hydrogen. In the manufacture of ferro-vanadium for the refining of steel there were nine cases of poisoning, one of which ended fatally.

Poisoning by Nitrogen Fumes

Poisoning by nitrogen fumes occurred in munitions manufacture in various industries, as well as in some which did not directly produce for war purposes. In German industries which worked for strictly military purposes there were several cases of poisoning by nitrogen fumes in the manufacture of nitric acid for the manufacture of explosives. Eleven deaths and a number of slighter cases of poisoning were reported. In a Hamburg super-phosphate factory, however, as well as in a sheet iron works in Breslau, there were also cases of poisoning by nitrogen fumes. These were due to the fact that the sulphuric acid used was a by-product of the manufacture of explosives and contained nitric acid and nitrogen substances (of the latter from 6 % to 0.5 %), which

produced nitrogen fumes. Nitrogen poisoning also frequently occurred in England in the manufacture of nitric acid, and in the subsequent nitration processes for the manufacture of explosives. In 1913 no cases of nitrogen poisoning were reported, while in 1917 there were 62, of which 5 ended fatally, and 27 in 1918, of which 7 ended fatally. Of the 1917 cases 22 occurred in the manufacture of nitric acid, 25, including 5 fatal cases, in the manufacture of picric acid and trinitrotoluene (trinitrotoluol), and 10 in the manufacture of gun-cotton. The report of the medical factory inspector states that it is probable that the cases reported from the explosives industry were only a small proportion of those which actually occurred. Dr. Bridge also points out that, though it is possible to become very rapidly accustomed to the fumes, so that a man can continue to work in an atmosphere which causes severe irritation of the mucous membrane to an observer, it is, nevertheless, not improbable that the respiratory organs are injured by this perpetual irritation.

Anthrax Poisoning

The incidence of another industrial disease, anthrax, was indirectly modified by the war, and in different directions. In Germany and Austria it decreased ; in England it increased. Anthrax became less frequent in Germany and Austria owing to the decreased use of imported material (horsehair, hides, skins); this in many cases led to the closing down of factories. It increased, however, after a temporary decrease, in a few districts where Hungarian hides were being more extensively used. In Frankfort-on-the-Oder there were two cases in each of the years 1915 and 1916, while in 1918 there were nine, though the number of persons engaged in the industry had been reduced by one-third. A similar phenomenon was observed in places, for example, Pardubitz, where hides from the Balkan States and Asia Minor were worked up. In England anthrax showed a marked increase. In the last five years before the war there were on an average 57 cases a year ; in 1916, 1917, and 1918, however, there were 105, 93, and 72 respectively. This increase mostly occurred in the wool trade, and was probably connected with the fact that wool, hides, and skins now began to be drawn from other countries. There were 19 cases in 1918 (10 of which were fatal), affecting persons other than industrial workers; these cases were caused by brushes imported from Japan and America or by brushes manufactured in England from Chinese horsehair.

Poisoning from Injurious Substitutes

A great deal of illness was caused in Germany and Austria by war substitutes, with the quality of which the population

of those countries are only too familiar. A great deal of interesting information on this point is given by Johann Müller ([11]), especially on conditions in Switzerland. He gives examples to show how the small-scale pharmaceutical industry lost its routine simplicity, inasmuch as the substances which had been used, e. g. for the production of aspirin, were no longer available, and he describes the new dangers which resulted. During the war, small and often ephemeral industries sprang up like mushrooms, most of them set on foot by speculators or by dubious middlemen. These industries often use large quantities of very dangerous materials and work under extremely bad hygienic conditions ; they have every reason to evade the factory inspection officials as far as they possibly can. Müller mentions the manufacture of bootpolish containing nitro-benzine, as the frequent cause of haemoglobinuria and severe poisoning among the wearers of the shoes. He also deals with the manufacture of washing powder, of which no less than 3,000 kinds invented in Germany during the war were dangerous and damaging to the clothes. He reports a death in a small works, which was due to the use, in large quantities and without any precautions, of nitro-benzine as a constituent of perfume.

Oils, Fats, and their Substitutes

Many cases of skin disease were caused in certain industries by lubricating oils, polishes, varnishes, and lacs. Even before the war there had been a tendency to seek substitutes for these products with a view to cheapness. During the war still further attempts were made in Germany and Austria to find substitutes, not only for animal and vegetable fats and oils, but also for mineral oil products and resin. The shortage of vegetable oils had, in fact, led to the prohibition of the use of animal and vegetable fats and oils for manufacturing purposes ([12]). Most of the substitutes were obtained from the distillation of coal and lignite.

The most popular lubricants in all manufactures, but especially for the lubrication of machinery in the metal trade, used to be petroleum products. During the war Germany was cut off from the principal sources of petroleum supply and was obliged to obtain substitutes by the distillation of coal tar and lignite tar, which were treated in such a way as to produce the necessary viscosity and purity. These substitutes caused many cases of skin disease, which are reported by German and Austrian authors ([13]) from nearly all the

(11) *Zentralblalt f. Gewerbehygiene*, 1919.

(12) German regulations dated 6 Jan. 1916 ; Austrian regulations dated 25 May 1916.

(13) NOBL, *Wiener Klinische Wochenschrift*, 1917, p. 70; and OPPENHEIM, *Arbeiterschutz*, 1919.

larger factory inspection districts. Even before the war eczema was sometimes caused by the use of impure products. During the war there were so many cases of skin disease of this kind in some factories that output was noticeably lowered owing to the number of absences. The parts of the body affected were not only the hands and arms, but also the face and neck, and those which came into continual contact with garments which had become impregnated with oil, namely, the arms, the upper part of the thighs, and the genital organs. In a sewing-machine factory at Potsdam 120 workers out of 1,000 were always suffering from " oil itch ". This number, however, gradually decreased when compulsory baths were introduced. In the opinion of the factory inspection official, Mr. Fischer who is one of the best authorities on industrial hygiene in Germany, the disease was due to " tar oil with resinous mixtures, which had had to be used in place of mineral oil distillations and neutral fats which were unobtainable. " An analysis of lubricating oil in the district of Frankfort-on-the-Oder showed that the " turpentine substitute " did not contain any fatty oils capable of saponification, any coal tar oils, benzine or similar products, or any mineral oil products, but consisted principally of unsaturated hydrocarbons, which easily became resinous, and a little oil of turpentine. Substitutes containing creosote caused 200 cases of illness during the summer in a factory at Frankfort-on-the-Oder.

As lubricants of this kind were not only used for lubricating machinery of all kinds, but also for other purposes, the same skin diseases appeared in other trades. Thus in the moulding department of a factory for fireproof goods, nearly the whole staff of more than a hundred persons were taken ill. A soft leather works, which had formerly used vegetable fat to make the leather supple, had to use a mixture of 90 % of mineral oils with a slight addition of animal and vegetable oils. At first the factory received the mineral oils in a refined form. From the summer of 1918 onwards, however, it used raw distilled products, which after a few weeks produced eczema among the workers. Even persons merely receiving and handling the finished leather goods in the army dépôts suffered from eruptions on the hands. Similar phenomena were observed in Austria. Eczema was caused by the finishing of shell cases, though the investigations undertaken by the district medical officer were positively stated to have proved the ultimate cause of this disease to be the penetration of iron dust and its retention in the skin ! The manufacture of these lubricants also produced skin diseases.

Many injuries were caused by the medical use of "war vaseline " and vaseline oil (14). The use of tar products also

(14) OPPENHEIM, *Arbeiterschutz*, 1918, and *Wiener Klinische Wochenschrift*, 1916 & 1917.

caused skin disease. For instance, tar was used for impregnation in a factory in Zwickau, which produced "shoe-sole substitute". The workers in all processes which brought them into contact with this tar and with the fabric impregnated with it became ill; the tar used for impregnation contained products combined with chlorine. In the opinion of the district medical officer the disease in question was tar acne. There were 27 cases and 5 of the workers were unfit for work for a considerable time. There were still more cases of chlorine acne in German factories which produced gas masks. Small discs of paper fabric which were intended to be used instead of discs of wire gauze to separate the different layers of the filling were saturated with per-chloride of naphthalene called "Perna", which had been melted at 140° C. Not only did the workmen engaged on this work become ill, but also those who only had to put the discs into the cartridges, and even in some cases those who had merely to sort the finished cartridges without actually coming into contact with the discs at all. Of ninety persons who came into direct contact with " Perna " in the course of nine months, about fifty were attacked, and although washing facilities, etc., were provided, it became doubtful whether the industry could be carried on. A Höhensonne apparatus ([15]) is said to have proved useful in the medical treatment of these cases. An attempt made to protect the workers from fumes and dust by good exhaust ventilation was entirely successful. As, however, Perna sublimates more easily and cannot be precipitated even in rooms fitted with special exhaust apparatus, it did damage, as the report in question states, in the neighbourhood of the factory. All the live-stock became ill, died, or had to be slaughtered. The drainage arrangements were therefore removed to a place where they could do no damage. Besides suffering from the skin disease, the workers in these industries were found to suffer from feebleness in the lower limbs and staggering gait.

The effect of all these substances, which in one way or another produced an irritating action on the skin, was made worse by lack of soap. It was often impossible to remove the harmful substances completely, and their effect was, indeed, sometimes intensified by unsuitable and irritating soap substitutes. These substitutes were occasionally in themselves sufficient to cause affections of the skin, e.g. in Marienwerder. Much danger was also caused by the shortage of india-rubber gloves, which were necessary in many processes, not only for the protection of the skin itself but also for protection against absorption of poison through the skin.

Many alterations had been introduced in the manufacture of varnish during the last years which preceded the war. Varnish was originally understood to mean solutions of resin

(15) A mercury vapour electric light.

(vegetable oils dried by air) in oil of turpentine, with or without the addition of an oil preparation produced by the treatment of linseed oil, to make oil varnish and volatile varnish respectively. Other spirit solvents are also used instead of oil of turpentine ; French polish is a spirit varnish of this kind. It has long been known that these varnishes often produce eczema, which is principally due, in the case of spirit varnish, to the adulterating qualities of the spirit, and in the cases of other varnishes, to impurities in the oil of turpentine. Even before the war many attempts had been made to substitute other substances for oil of turpentine, both in order to be independent of foreign countries and for the sake of cheapness ; this resulted in the use of benzine and then of distilled tar products, such as benzol and phenol. Benzine and benzol, however, were also used as solvents for the specific purpose of producing colours which would dry quickly. Even before the war benzol was more and more often preferred to benzine on account of its lower price. Paints manufactured by these processes were mostly used in shipbuilding, and when the work was carried on in small cabins between-decks and elsewhere, cases of poisoning were caused. The first case of poisoning due to paints containing benzine in 1893, and the more frequent cases caused by the use of benzol since 1905, were reported in detail by the Hamburg factory inspector, Dr. E. Schaefer, in 1910. Benzine is a derivative of petroleum and, as is known, was very difficult to obtain in the Central European countries during the war. As there was a great shortage both of benzine and oil of turpentine, benzol had to be more and more used as a solvent. Reports received from all parts of the country mention cases of general poisoning by paints containing benzol as well as skin diseases attributable to benzol. Such reports were received from carriage-building works, from ship-building yards, for which special regulations had already been issued by the Hamburg officials and later, on 18 July 1917, by the Ministry of the Interior, as well as from the sheet metal workers. Other paint and varnish solvents, such as solvent naphtha and acetone, also caused cases of poisoning. Finally, in a factory in the Potsdam district the shortage of benzine led to the use of trichlora-ethylene for cleaning and removing grease from metal parts ; this produced an irritation of the skin and had a numbing effect.

It was not only in Germany and Austria, however, that these substitutes had to be used. A case of fatal poisoning is also reported from the Netherlands, where a worker at the rolling machine of an india-rubber factory succumbed, because the rubber solution contained four-fifths to five-sixths of benzol. It was also found in a factory for gas masks that the " benzine " which was used as a solvent consisted of benzol, toluene, and xylene. Again, in a bicycle works the solvent for rubber was raw benzol. It is hardly necessary

to emphasise the fact that this shortage of turpentine and animal and vegetable fats, which led to so many industrial diseases and cases of poisoning, and, above all, to such an immense number of cases of skin disease, did not exist to the same extent in England.

The danger from these paints and lacs was, however, not nearly so great as that from the varnish used for aeroplanes and aeroplane wings. India-rubber fabric proved unsuitable as a covering for aeroplanes and aeroplane wings([16]); therefore wings, propellers, and body covering, as well as balloon fabrics, were made of linen, silk, etc. ; this was then impregnated with a varnish by painting and spraying; each layer was polished with sand-paper and the final result was a firm, smooth, waterproof surface. Nitro-cellulose, which is used in many other varnishes of this kind, was replaced, on account of its inflammable character, by acetylcellulose, which is essentially soluble only in tetra-chlor-ethane, chloroform, acetone, or tetrachloride of carbon. A certain percentage of this solution can, however, be replaced by benzol and spirit. The most important of these solvents is tetra-chlor-ethane, which was used as a commercial solvent by the *Bosnische Electricitäts A. G.* in Vienna as long ago as 1907. It is impossible to say how long it has been used on a large scale, partly because the varnish factories keep their trade secrets very carefully, partly because their manufactures are continually being changed, and even those which are sold under the same name are not always made up on the same formula. A death was reported at an early date in the Mühlhausen aeroplane works. It is impossible to say how many cases occurred later and were not reported to the authorities. The need for an investigation was first realised at the end of 1913. A factory inspector noticed that there were two simultaneous cases of jaundice in the same factory and asked the district medical officer if this were not due to lead poisoning. The doctors attached to the sick fund and the hospitals had never expressed any suspicion of this type of poisoning; the patients themselves mentioned the use of paints and they then diagnosed the cases as "lead" poisoning. This shows how necessary it is to spread a knowledge of industrial diseases among doctors and to supply expert medical advice on industrial diseases to supplement factory inspection ; for when enquiries were made in this branch of the Johannisthal Aerial Transport Company, it was found that of fifteen varnishers, every one either was, or had been, ill, with the exception of one who had only been working for four weeks; two of the workers had died. Further enquiries showed that there had also been cases of poisoning in other aeroplane works, some of which had only recently been set up.

(16) Cf. statements of Grimm, Heffter and Joachimoglu in *Vierteljahresschrift f. gerichtl. Medizin*, Vol. XLVIII, *Suppl.*

Tetra-chlor-ethane ($CHCl_2—CHCl_2$) produces an effect similar to that of chloroform (tri-chlor-methane $CHCl_3$), but is four times as poisonous as the latter, and its haematolytic effect is 7.6 times as great. Its effect is shown, on the one hand, by nervous symptoms (trembling, paraesthesia, disappearance of the patellar reflex, and pains in the head and joints), and, on the other hand, in sickness, nausea, acute jaundice, and atrophy of the liver ; death occurs in the form of acute jaundice and atrophy of the liver ; similar phenomena have occasionally been observed after a long chloroform narcosis. The disease, once started by the poison, often makes uninterrupted progress ; thus one man, although he ceased work as soon as jaundice appeared, nevertheless died three weeks later. Among the varnishes used in the factory first investigated which were analysed in the Chemical Institute of Berlin, the varnish called "Aviatol" was found to contain 50% of tetra-chlor-ethane, and that called "Quittner's Emaillit" 30% ; another varnish, however, which was used in other factories, though apparently only to a small extent, was free from tetra-chlor-ethane. The great danger to aeroplane workers who use tetra-chlor-ethane arises from the fact that the surface from which evaporation takes place is very large. The fumes are heavier than air, sink to the ground, and are liable to cause danger to other workers who are working in the same room, especially if they are working at a level lower than the surfaces which are being varnished. For example, in a German factory a locksmith, and in an English factory a woman engaged in sewing, who were working with the varnishers became ill. On account of their weight the fumes can only be removed by very strong exhaust ventilation from below, while at the same time fresh air, which in winter should previously be warmed, should be admitted in the upper part of the room. If these ventilation arrangements are not quite efficient, or if they cease to work, cases of poisoning are liable to occur. In the above mentioned works there were ten cases of poisoning, one of which ended fatally, in the first half of 1914, even after ventilation arrangements had been introduced. As there exist much less dangerous varnishes which can be used in aeroplane manufacture, the Royal Prussian Scientific Medical Commission suggested that varnishing materials which contain tetra-chlor-ethane should be prohibited ; even before the war the use of varnishes of this kind was forbidden by police order in many districts of Prussia. The aeroplane factories wished to be allowed to use varnish containing up to 15% of tetra-chlor-ethane, but their request was refused by the higher authorities ; the prohibition therefore remained in force. The marked development of the aeroplane industry in the war made the question of aeroplane varnish of still greater importance, and the prohibition of varnishes containing tetra-chlor-ethane in the Prussian districts, where aeroplanes were prin-

cipally manufactured, protected the workers from serious dangers. In Bavaria there were nine cases of poisoning, one of which ended fatally.

In the English aeroplane factories, on the other hand, a large number of workers became ill. At the end of 1914 there were 27 aeroplane works, employing 6,500 workers, 300 of whom, both men and women, were engaged on varnishing ; but the number of persons exposed to poisoning was much greater, as the varnishing rooms were not separate from the others. In large works the output was three aeroplanes per week, and 40 lbs. of varnish were used; the faster the varnish dried, the better it was considered to be, and for this reason many factories preferred varnish containing tetra-chlor-ethane. At the end of September 1916 the authorities had received notice of seventy cases of jaundice , twelve of which ended fatally, in addition to a number of slighter cases of poisoning. This necessitated a close investigation of the subject, and at the end of September 1916 the manufacture of varnish containing tetra-chlor-ethane was generally given up in England ; individual factories had already abandoned its manufacture at an early date.

An analysis of two German varnishes undertaken at Berlin in 1913 had shown a tetra-chlor-ethane content of 50% and 30% respectively. The analysis of British varnish by British factory inspectors in 1914 revealed only a content of 12% and 11.5%. In 1915, however, the analysis of German and English varnishes, which was undertaken by Dutch factory inspectors, gave quite different results. One British varnish contained 50-60% of tetra-chlor-ethane, while in the case of two German varnishes, the principal solvent was acetone. One also contained 5-10% of tetra-chlor-ethane, while the other only showed traces of this substance. Advice was, therefore, given by the Dutch authorities to use British varnish as little as possible.

The solvents which are used instead of tetra-chlor-ethane are, however, by no means indifferent, and even if they do not cause serious or fatal poisoning, they nevertheless involve some inconvenience and slight injury to the workers. Formic acid, which had been added to the formic ether used as a solvent, or else had been formed by the disintegration of the latter, caused irritation of the mucous membrane ; ketone, methylated alcohol, and acetone, caused headache, giddiness, and sickness. According to English reports, the derivatives of acetone which were used had a more stinging smell than acetone. The ketone which was used was an impure mixture of methyl-keton, methyl-ethylketon, and higher homologous substances. These reports also state that benzol is a constituent of all aeroplane varnishes. In any case, however, cases of illness caused by these varnishes are not to be compared in frequency or gravity with those due to tetra-chlor-ethane varnishes. In England in 1917, although the number of

factories had been quadrupled and the number of workers had increased tenfold, only eleven cases were reported, and a careful medical examination of the workers employed in the varnishing rooms only showed a slight degree of anaemia. In these factories, however, as in those of Germany, care had been taken to provide efficient ventilation arrangements, such as exhausts from below and a supply of fresh air from above ; efforts had also been made to arrange ventilation in such a way that the air should be completely changed thirty times in the hour at least.

In dealing with aeroplane varnish, we have already touched on those poisonings the frequency of which was due to the existence of war industries. The aeroplane industry is perhaps not to be strictly defined as a war industry, as is proved by the history of tetra-chlor-ethane poisoning which we have given above; nevertheless, aeroplane manufacture received a great impetus from military requirements. We will now proceed to deal with those poisonings which are attributable to war industry properly so-called.

Poisoning by Nitro-Compounds

Very extensive use was made in war industries of nitro-compounds, and, in particular, of aromatic nitro-compounds. Above all, large quantities of dinitrobenzol and dinitrotoluene were used. These poisons are introduced into the system not only by the inhalation of dust and fumes, but more especially by means of absorption through the skin, as dinitrobenzol combines with the fatty substances of the skin and thus penetrates the upper layer. The illness is generally sub-acute or chronic; as in all types of poisoning, individual pre-disposition plays a large part. The symptoms generally appear after two to four weeks of work; the slighter cases begin with giddiness, languor, and headache, with more or less marked anaemia and slight cyanotic colouring; in serious cases the subjective symptoms are more strongly marked, and the colour of the skin ranges from sallow to leaden colour, while the nose and ears become dark blue; the mucous membrane of the lips is also dark blue (cyanosis); in exceptional cases a yellow colour (haematogenous icterus) is more noticeable. The course followed by many serious cases is from liver disease to acute jaundice and death in the form of acute jaundice and atrophy of the liver. The reflexes of the pupils generally cease, and the pupils themselves are very much contracted. Stupefaction and staggering gait have also been observed.

Aromatic nitro-compounds act principally as blood poisons; they cause the formation of methaemoglobin and the destruction of the red corpuscles. Women are particularly susceptible to these poisons. Considerable haemorrhage

occurs at the period of menstruation and, according to Curschmann (17), acute jaundice and atrophy of the liver is particularly frequent among women. But the extreme difficulty of deciding how much to attribute to sex factors and how much to the work on which the worker is engaged is proved by the fact that in some factories there were fewer cases of poisoning among the women than among the men. The remarkably injurious effects of alcohol in this type of poisoning also deserve note. It has often been observed, both before and during the war, that workers who handle aromatic nitro-substances do not become seriously ill until they have taken alcohol, or that a comparatively slight attack becomes serious owing to the use of alcohol.

The poisonous nature of all these compounds has long been known. As early as 1907 regulations were issued in England concerning the manufacture of nitro- and amido-derivatives of benzine and of explosives involving the use of dinitro-benzine and dinitrotoluene. In Germany the Imperial Ministry of the Interior in 1911 issued regulations for the equipment and working of factories in which dangerous nitro- or amido-compounds are manufactured or regularly recovered in considerable quantities. The chief points in these regulations are: lofty, well-ventilated work-rooms (18); smooth walls and floors which can easily be washed (18); processes so arranged that the workers come as little as possible into contact with the substances which are being manufactured; efficient exhaust ventilation to remove dust and fumes as they are produced; special working uniforms; prohibition of the use of alcohol (18); washing and bathing arrangements (18); prohibition of the employment of women and children (18); medical supervision of the workers' health; and instruction of the workers as to the danger they incur. The sudden immensely increased demand for explosives at the beginning of the war made it impossible to install absolutely complete safety arrangements. It was not easy to provide lofty, well-ventilated work-rooms, waterproof floors and bathing arrangements, or even cupboards and special working uniforms as they were required. Mobilisation made it impossible to maintain the exclusion of women from most of the processes. Again, work was done against time, managers were inexperienced, and a number of totally unskilled workers had to be employed. In the course of the war the greatest attainable degree of safety in working conditions was gradually introduced. It was those places and factories which were least accustomed to the use of dinitrobenzine which had the largest number of poisoning cases; where the authorities, factory inspectors, employers, managers, and workers had had more experience in the manufacture and use of these

(17) *Zentralblatt f. Gewerbehygiene*, 1918.
(18) Omitted in the British regulations.

poisonous substances, they were best able to avoid or lessen danger at the outset; others had to acquire this experience and learn to apply it in the course of the war itself. Thus the Industrial Medical Officer for Bavaria states that the sickness insurance funds reported altogether 1,000 cases of dinitrobenzine poisoning from the beginning of 1915 to the end of the war, while 12 fatal cases came to the knowledge of the authorities. Of these 46.8% of the workers in one factory (calculating on a basis of full-time work) became ill in February 1917; in June of that year the proportion was 30.8%; in May 1918 only 16.4%; during the winter the number of cases decreased; the average number of cases of poisoning per month over the whole period 1916 to 1918 was 12.2% of the full staff of workers; in other factories the proportion was still higher. It was reported from another factory in Schleswig that during the hot season there were at first 8 to 10 workers per day under treatment at the medical station of the factory; the next summer there were only half as many, though the number of workers had nearly doubled, and only three fatal cases. Similar reports were received from many other districts. Fortunately slight and passing attacks of illness were the rule. Everywhere improved working arrangements, shortening of hours, in some places the use in summer of the cooler part of the day for working hours, the medical inspection of the workers before their engagement, and their medical supervision afterwards, proved beneficial. Factory doctors had necessarily also to make themselves sufficiently familiar with the peculiar symptoms which appear.

TNT and DNB Poisonings

In Germany it was chiefly *dinitrobenzol* which was used as an explosive, sometimes alone and sometimes combined with other substances. *Trinitrotoluene*, however, which appears to have played an altogether preponderant part in the manufacture of explosives in England and America, was also considerably used. This introduces a still unsolved problem : is trinitrotoluene poisonous or not ? Before the war English and German investigators undoubtedly considered trinitrotoluene non-poisonous; English investigators ([19]) considered it ordinarily non-poisonous and believed the substitution of TNT (trinitrotoluene : Trotyl) for dinitrobenzol to be of the greatest advantage to the workers. It is certain, however, that the employment of trinitrotoluene in war industry led to severe cases of poisoning; such cases were very numerous in England and America, much more so than in Germany. In Prussia one death from TNT was reported in Wiesbaden, and in Merseburg four deaths from acute jaundice and atrophy

(19) Prosser.

or the liver were traced to the handling of TNT ; thirteen cases, with seven deaths, from acute jaundice and atrophy of the liver occurred in Potsdam and scattered cases in other places. Altogether, according to Koelsch [20], who has collected all these records and compared them with the English records, and on whose work the following remarks are partly based, only twenty such severe cases ending fatally were reported in Germany during three and a half years of war. Koelsch, who for over three years had opportunities for uninterrupted observation of hundreds of workers engaged on TNT, was personally unable to verify a single death ; he only recorded slight symptoms, e.g. irritations of the upper air-passages, slight modifications of the blood with formation of methaemoglobin, cyanosis, languor, headache, difficulty of breathing. In an experiment tried on himself, in imitation of an English example, by applying TNT to his forearm and fastening a bandage over it, only a slight reddening and swelling of the skin followed and soon vanished. Koelsch concludes from this that these cases of poisoning occur in groups, and Fischer [21] drew the same conclusion from the Potsdam cases. Both investigators draw the inference that the TNT prepared at the time when most of the cases occurred was of a quality different from that which was prepared at every other time. They came to the conclusion that TNT is in itself non-poisonous, but that impurities, which under certain circumstances adhere to TNT when employed in manufacture, have been the cause of the poisonings observed.

In England the state of affairs was altogether different. During the war there were 181 cases of jaundice due to TNT poisoning, with 52 deaths in 1916 ; 189 with 44 deaths in 1917 ; 34 with 10 deaths, in 1918 ; these figures include only the severe cases. For every one of these cases there were, according to the records, at least thirty with slighter symptoms, such as sallowness, debility, disturbances of the digestion. In addition, thirteen severe cases of progressive anæmia were reported, accompanied by destruction of the red bone marrow (without atrophy of the liver), ending in death. Some cases developed a very considerable time after employment had been discontinued. Thus a case of acute jaundice and atrophy of the liver is reported, which developed, seven months after work had been given up, in connection with a skull wound, and two cases of aplastic anæmia, which developed respectively four and nine months after a change of work, and ended in death, one after six and the other after seven, weeks. In August 1916 11% of the workers in the Government munition factories were suffering from sickness ; in January 1917 only 1%. Altogether over 50,000 workers had been engaged on TNT ; of these 0.36 per thou-

(20) *Zentralblatt f. Gewerbehygiene*, 1918.
(21) *Ibid.*, 1917.

sand suffered from jaundice in 1916, and 0.38 per thousand in 1917 ; the mortality was 0.1 per thousand and 0.09 per thousand during these two years. The English reports give some striking particulars. The first deaths only came to the knowledge of the authorities in February 1915, comparatively late; it is probable, in my opinion, though certainty is here impossible, that there were earlier cases. The number of cases seems to have increased towards the end of 1915.

The position in the American factories was terrible. In the first seven and a half months there were 17,000 cases of jaundice with 475 deaths ; in the next twenty months, 7,000 cases with 105 deaths. These figures are taken from the Annual Report of the Dutch Factory Inspectors. This report rightly remarks that the total number of cases of TNT poisoning which occurred in the war industries of all countries will always remain a secret; this remark also holds good for the other types of poisoning in war industries. These figures quite obviously make it impossible to maintain that TNT is non-poisonous. The TNT manufactured in the munitions industry in England and America must clearly have been poisonous. But some explanation is required as to why TNT, which was once considered by English investigators to be practically non-poisonous, and which is still so considered by German investigators, should now prove so poisonous. The suggestion that it is now employed in much greater quantities than before, and that many more persons come into contact with it, among them persons with a more special susceptibility to it, cannot be accepted as an altogether satisfactory explanation. The view to which many English investigators appear to incline —that the personal idiosyncracy of individuals is the cause of the cases recorded—is in such strong contradiction to the views adopted in this article, views which make every allowance for the part played by personal predisposition in industrial poisonings, that it does not appear to me by any means conclusively to solve the problem of the poisonousness of TNT. In my opinion there is a *prima facie* probability in the argument that the same substances formerly regarded as non-poisonous and now regarded as poisonous were not absolutely identical, that the infrequency of poisonings in Germany and the much greater proportion of cases in England and America are to be explained by a difference in the material ; that, while the principal substance remains TNT, Koelsch is probably right in inferring the poisonous effects observed, not to the TNT itself, but to its impurities. The theory that the TNT employed in England was not entirely identical with that employed in Germany is confirmed both by the greater incidence of cases of poisoning observed in England, and further by Koelsch's experiment mentioned above, imitated from that of White ([22]), an experiment which in his case produced

(22) *Lancet*, 1916.

only a slight irritation of the skin, while in White's it produced dermatitis lasting a month. If English TNT contained far greater impurities than the German TNT, this is possibly the result of the different standing of the chemical industry in either country before the war; the German chemical industry, especially in its work on coal-tar derivatives, was far in advance of the English. It is quite probable that in the first years of the intensive production of TNT, the English product was much less pure than what had been previously manufactured. It is also possible that the difference should be traced back to a difference in the original base; English coal tar contains more disease-producing elements than the German, as appears from the greater frequency of tar cancer, to which Koelsch has drawn attention. Again, the admixture of other products may have considerable effect, as is illustrated in the combined effect of alcohol and benzol mentioned above. Even if the example given by White and Hay ([23]) does not hold good, it is still quite possible that an impurity, not poisonous in itself, may strengthen the effect of a slightly poisonous substance by making the skin more penetrable by such substance. Thus, besides the possibility of pollution with a directly poisonous substance, pollution with a substance capable of increasing the otherwise slightly poisonous effect of TNT must be taken into account.

Some of the impurities to be found in TNT are known; what further impurities exist, which may in one way or another give rise to poisoning, are questions requiring further investigation. Investigations which have so far been made by means of experiments on animals do not appear to have been sufficiently directed to this point. It should, however, be mentioned that, after many experiments, Dr. Moore and his collaborators succeeded, by the employment of enormously large doses, in producing in three cases anatomically ascertainable modifications of the liver, and in one case jaundice, and that the first two were produced with polluted TNT. The impurities that have so far been found are tetranitromethane ([24]), which is the undoubted cause of symptoms which will be discussed later; β and γ TNT and dinitrotoluene ([25]), which does not appear to be more poisonous than TNT itself; mononitrotoluene was found by the chemist of the Dutch Government munitions factory in American raw TNT. It is noticeable that in Holland the managers of the munitions factories attach importance to the use of purified and well-washed TNT (Trotyl). Serious cases of poisoning did not occur in Holland; on the other hand, manufacture was neither on so great a scale nor so hurried as in the belligerent countries. German, English, and American

(23) *Lancet*, 1901.
(24) FISCHER, *Zentralblatt f. Gewerbehygiene*, 1917.
(25) MOORE, *Medical Research Committee, Special Reports Series*, No. 11.

figures, nevertheless, prove one fact, and that is the enormous diminution in the number of cases of sickness which was to be observed in the course of the war; this proves how much may be done by means of hygienic measures to reduce the frequency of poisonings. When the war began, work was everywhere carried on in partly improvised factories, against time, and without regard to sanitary precautions, though even in this respect the figures indicate substantial differences between the countries.

In France TNT was less used; its place was taken by picric acid and dinitrophenol. Up to August 1916 the record had been 27 deaths from poisoning by these two substances and many slighter cases. Efforts were made to ascertain which of the workers were in danger by urine examinations conducted by a pharmacist on the Derrien test method; if there was a positive and increasing reaction lasting several days, the worker was placed under medical supervision and was made to stop work on the first appearance of any symptoms. Later, in 1918, the use of dinitrophenol became necessary in England, and an English medical expert visited the French factories; in consequence of the precautions taken as the result of this visit, no cases of sickness from dinitrophenol were observed in England; there was an isolated case in one factory in 1916.

Poisoning from Various Causes

Some other poisonous bodies of the aromatic series should be noted. *Trinitronaphthaline* in the form of powder produced an acute irritation of the skin, but the harmful effects disappeared as soon as it began to be employed in granular form only. *Trinitroanisol* was also strongly irritating to the skin, especially when liable to form powder, and the strictest cleanliness was therefore necessary. In the employment of *nitroglycol* powerful exhaust apparatus was necessary, otherwise every worker dealing with it suffered from rush of blood to the head and giddiness.

Dinitrochlorobenzol produced severe dermatitis. *Picric acid* was used by military shirkers for inducing jaundice; in such cases the urine did not contain any yellow colouring matter, but only picric acid. Picric acid produced yellow-green colouring of the worker's hair and "canary birds" on the exposed parts of the body; but as regards sickness, there were only occasional cases of irritation of the skin and mucous membrane, especially in hot weather; complaints of stomach troubles, headache, and giddiness were more common. According to one report, anomalies in menstruation, and according to another, acceleration of the heart's action, were observed, and one case of perforation of the septum of the

nose, as in the chrome industry, is reported. The sickness funds reported a general increase in sickness, but serious cases seldom occurred; Koelsch only knows of one case.

Greater injury is inflicted by *tetranitromethane* ($C(NO_2)_4$), which is employed in the explosives industry. Breathed in as gas it chiefly affects the respiratory tracts as a strong irritant, produces coughing, a sense of pressure on the chest, and catarrh of the air passages, and in several cases has led to pulmonary oedema or croupy pneumonia and death. This effect is easily explained by the four NO_2 groups. At the same time there is also a general effect on the blood (methaemoglobin-formation). $(NO_2)_4$ acquires its chief significance as an impurity of TNT ([26]).

The number of cases of poisoning occurring in the manufacture of gas bombs, on account of the highly poisonous gases employed, appear to have been comparatively few, in Germany very few indeed. Two English munitions works manufacturing *phosgene gas* reported 27 cases of phosgene poisoning in 1917, and 69 in 1918 ; many cases occurred in the course of some alterations to the premises. In a German factory, after the failure of a process involving "*Perstoff*" (a material used in gas warfare), some of this product escaped through the factory drain, which ran into a brook and caused the bank of the brook to become charged with phosgene gas; to this a worker fell a victim. A case of phosgene poisoning also occurred in connection with the manufacture of derivatives. In one factory at Wiesbaden fluid phosgene escaped through overpressure due to inadvertence, and penetrated into the factory courtyard, causing six workers to lose their lives. Skin irritations appeared in Germany in connection with the filling of grenades with an irritant gas "*T Stoff*" ; also irritations of the nasal mucous membrane and facial swellings in filling grenades with an irritant material. The Austrian factory inspectors' reports contain no information on poisoning in munitions work. Apparently all dangerous processes took place in Government factories under the War Ministry, where factory inspectors had no legal right of entry.

A consideration of precautionary measures taken in the different countries shows that in Germany the factory inspectors, police authorities, and military authorities paid most attention to a strict observance of the 1911 Order of the Imperial Ministry of the Interior, while in England attention was directed to the strict observance of the 1907 Order. The number of cases of poisoning decreased in proportion to the degree in which it was possible to carry out these regulations; in Germany the introduction of female labour was the only point in which they were contravened. In addition to the ordinary sanitary pecautions, there was one measure which

(26) KOELSCH, *Zentralblatt f. Gewerbehygiene,* 1917.

proved exceedingly necessary and useful ; this was the medical selection, and to a still greater degree the medical supervision, of the workers. In England, as in Germany, this constant medical supervision of workers exposed to danger, made by doctors who were familiar with the processes employed and with the symptoms to be expected, was the most effectual precaution against the occurrence of sub-acute and chronic poisoning. Arrangements had naturally to be made for the proper instruction of these doctors. In Germany this was done, partly by circulating a Memorandum for medical men drawn up by the Imperial Health Office, on the advice of Curschmann and other experts, relating to poisoning by nitrated carburetted hydrogen compounds of the aromatic series, and partly by courses of lectures for the profession, which were delivered at certain centres, as, for instance, at the Hygienic Institute of the University of Halle. Provision was also made for speedy attention to the sick in the factories ; not only were doctors and nurses in attendance, but all necessary appliances, such as oxygen apparatus and medicines were also ready to hand in the factories themselves. The workers were themselves instructed by means of leaflets. Finally, the German Federal Council, by resolution of 12 November 1917, directed that compensation under the accident insurance law was to be paid in the case of deaths due to nitrated carburetted hydrogen compounds of the aromatic series employed in the preparation of munitions.

It was not merely what happened in the factories, however, which proved the usefulness of expert medical advice. The war proved the extraordinary value of the collaboration of the medical profession in factory inspection. Medical knowledge alone can detect the appearance of new diseases and ensure the prevention of industrial sickness. The experience of the war has caused Prussia to imitate the practice of Bavaria and Baden in instituting an industrial medical service. The introduction or extension of compulsory notification of industrial diseases is also being considerably discussed in Germany today as a result of the experience gained during the war. The Frankfort Institute of Industrial Hygiene has led scientific research on these problems ([27]). The instruction of the medical profession in industrial hygiene and industrial disease will also receive more attention in the future at the universities.

England was better prepared for the prevention of war industrial diseases, apart from the fact that her workers had not to suffer from the special diseases resulting from the use of substitutes. Compulsory notification of certain industrial diseases had been introduced many years previously; certain

(27) *Schriften aus dem Gesammtgebiet der Gewerbehygiene.* Herausgeg. v. Institut f. Gewerbehygiene in Frankfurt a/M. Heft 6, FRANCKE und BACHFELD, *Die Meldepflicht der Berufskrankheiten.*

forms of industrial poisoning had been compensated as accidents. During the war compulsory notification was extended to toxic jaundice, to the jaundice of acute yellow atrophy of the liver, which appears as a fatal disease in connection with tetra-chlor-ethane, dinitrobenzol, trinitrotoluene, and other forms of poisoning; this was on 27 November 1915; on 7 July 1915 and 6 May 1916 these poisonings were also defined as industrial diseases entitled to compensation as accidents. Above all, the necessary preliminary step to all compulsory notification and compensation had been taken: there was an adequate supply of men with a knowledge of industrial hygiene and industrial disease. The "certifying surgeons" had for years past been officially entrusted with the supervision of workers in dangerous processes, and there were also available a number of medical factory inspectors directed by a Chief Inspector. The war made it necessary to find more men fit to supervise industrial processes. Fifteen members of the medical profession, among them eleven women, were appointed to supervise the work of Government shell-filling factories. An Inter-Departmental Committee was appointed for advising the Ministry of Munitions on measures for the prevention of TNT poisoning. On the advice of this Committee precautionary regulations for shell-filling factories were issued. Another Special Committee was appointed by the Director-General of the Army Medical Service, for the purpose of preparing reports on sanitary conditions and arrangements in the munitions industry on the basis of information supplied by subordinate officials. This Committee has issued eighteen special reports. As already mentioned, a doctor was sent to France to study the sanitary side of the munitions industry; by his advice the manufacture of poison-gas was medically supervised from that time on. An even wider appeal was made to the medical profession. Memoranda and pamphlets were published for their use; medical societies discussed the causes of poisonings recorded during the war, and the attention of the whole of the profession was thus directed to the nature and significance of the new diseases.

It is to be hoped that the war will cause progress to be made in all countries for the protection of the health of industrial workers. A large number of doctors must be available for supervising industrial processes; the whole medical professsion must be more thoroughly instructed in industrial hygiene and industrial diseases; eventually the compulsory notification of industrial diseases must be introduced and these diseases must be defined as accidents for purposes of compensation.

INDUSTRIAL RELATIONS

The Growth of Trade Unionism since 1913

Introduction

In February last (1) the International Labour Office published a report on trade unionism, under the title "The Growth of Trade Unionism during the Ten Years 1910-1919". The present article is designed to bring that report up to date and considerably to extend it, in the light of information now available for thirty different countries, referring more especially to the years 1913, 1919, and 1920.

In most cases the statistics here given are based on returns voluntarily made by the trade unions to their governments, or published in trade union or other periodicals. The figures for the countries, therefore, vary both in completeness and accuracy. In some countries the trade unions are centralised in great national federations, and in these cases the figures may be regarded as nearly complete. Unions which are not affiliated to the central organisation are generally small ones. In the case of other countries, where there are a number of isolated local organisations, the available information is far less reliable. From year to year, however, returns become more complete, arrangements for collecting trade union statistics improve, and omissions become less considerable. Thus the increase in membership which appears to have taken place in all countries must perhaps to some extent be attributed to the greater completeness of the returns.

The definition of the term "trade union" is somewhat difficult and varies from one country to another; an association which in one country would be called a trade union bears a different name in another. Account has here been taken rather of the idea than of the name.

In some years there are no available figures. In these cases approximate estimates have been made either from the figures of the preceding and following years, or from the calculations of the competent authorities of the country. All estimates contained in the following tables are, however, distinguished by a special sign (*).

Generally speaking, but especially as regards belligerent countries, the figures referring to the years 1915 to 1918 are not of great value. Trade union statistics were almost everywhere disorganised by mobilisation. In some countries

(1) Inter. Lab. Off. *Studies and Reports, Series* A, No. 17; price 10d..