LEAD POISONING

LEAD POISONING:

FROM THE INDUSTRIAL, MEDICAL, AND SOCIAL POINTS OF VIEW

Haven Emerson
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LECTURES

DELIVERED AT

THE ROYAL INSTITUTE OF PUBLIC HEALTH

BY

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E. O. O.

PREFACE

The growing interest taken in the subject of lead poisoning is my excuse for the publication in book form of the lectures delivered in the Royal Institute of Public Health, Russell Square. No metal is more widely used in the arts and manufactures, and none lends itself to the increasing requirements of modern life and industrial development more than lead. In the following pages I have tried to place before all who may read these lectures the channels by which lead gains entrance into the body, the effects of the metal upon the organism, and how these effects may be got rid of. Although trades in which lead or its compounds are used will always be more or less dangerous, the extent to which industrial lead poisoning has been reduced is an excellent illustration of what legislation has accomplished, and of the good effected by Home Office inspection and regulations. What has been accomplished in this respect is but earnest of what can be. In the hope that by throwing additional light upon the subject such an object may be attained, this little book is launched upon the medical profession and the public.

In the Appendix are printed, by permission of the Controller of H.M. Stationery Office, the Factory and Workshop Orders relating to lead poisoning.

THOMAS OLIVER.

7, Ellison Place,
Newcastle-upon-Tyne,
August, 1914.

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FROM THE INDUSTRIAL, MEDICAL, AND SOCIAL POINTS OF VIEW

Of the various metals used in the arts and manufactures, none has, next to iron, a wider application than lead. Colours made from lead were in use long before the Christian era. When indiscriminately employed, lead and its compounds may become a source of much suffering. The number of trades in which the metal and its compounds are used is large. A few years ago Layet, a French physician, enumerated 111 industries in which lead is employed; but, as new trades are being constantly developed, there is a growing demand for lead in one form or another. There are few industries, therefore, with which the metal is not directly or indirectly concerned.

Lead mining and lead smelting are old British industries. Blocks of metallic lead have been found in the Midlands with the Roman arms stamped upon them. The world's production of pig lead is estimated to be upwards of 1,200,000 tons per year. In our own country lead mining is confined to Derbyshire and the North of England, also to the Lowlands of Scotland. Formerly it was an important industry and a source of great wealth. After the discovery and introduction into this country of Spanish and Australian lead, the mining of the metal in Great Britain declined, owing to small prices and the fact that the foreign ores contained larger percentages of silver. Within recent years there has been a revival of lead mining in the North of England. As the mining is carried on in the remote dales and sparsely-populated moorland districts of the northern counties, where housing accommodation is inadequate, barracks have been erected for the men to sleep in. Housing conditions are better now than they were years ago. At that time, when the mines were in full working order, the barracks were hotbeds of tuberculosis. The rooms were ill-ventilated and overcrowded; the windows did not open; the beds were arranged in rows too close to each other. No sooner, almost, were the beds vacated than they were occupied by men coming in from the other shift. Indiscriminate spitting was common, and, as many of the miners suffered from bronchitis, the expectoration was freely distributed upon the floor. Others, who lived at home, were obliged, when heated and tired after their hard day's work, to walk two or three miles across a bleak and wind-swept country, exposed to the weather. Hence the prevalence of bronchial affections in lead miners, and a preparation of the lungs for the reception of tubercle bacilli. Lead mines, unlike coal mines, are not ventilated. Some of them are wet and are entered by a drift. Entrance into and exit from other mines can only be accomplished by means of a series of ladders.

Since there are no inflammable gases in lead mines, the men work with naked candles. Gunpowder is the explosive used to bring down the rock. Where powder has been fired, it requires a long time for the smoke to clear away and for the dust to settle. Miners who work in such an atmosphere become liable to bronchial and pulmonary catarrh, and especially to that type of lung disease caused by dust, known as silicosis, in which the spongy texture of the lung becomes converted into fibrous tissue. Miners who are the subjects of silicosis incur the risk of having tubercle subsequently grafted upon the injured lungs. Statistics show that pulmonary tuberculosis is more prevalent among lead miners than among other persons living in the same district. Owing to the wetness of the mines, the men are liable to rheumatism.

Apart from these maladies, lead miners are not an unhealthy class of men. Socially they are a contented body of men, frugal, temperate, and thrifty. They do not suffer from lead poisoning, because the lead in the ore is in almost the pure metallic form, known as galena. This exemption from plumbism does not apply to lead miners all the world over. A decade and a half ago, at the Broken Hill Mines in Australia, several of the miners suffered severely—there were even a few deaths—owing to the ore being in the form of carbonate. This ore, known as *cerussite*, is, practically speaking, a crude white lead. It differs in composition from the ordinary white lead of commerce in the fact that, while the manufactured article is a hydrated lead carbonate or a mixture of hydrate and carbonate, cerussite is crystallized lead carbonate. The ore is friable, breaks down readily into a fine powder, is easily blown about the mine in the form of fine dust, and possesses, therefore, all the dangerous properties of the white lead of commerce. The men who mined the cerussite suffered heavily in their health; and no wonder, since in the sputum of three of them 2·0, 1·8, and 1·6 grains of lead were found respectively. The 200-foot layer of carbonate ore at Broken Hill has been pretty well exhausted, so that at Broken Hill, as in England, the ore now raised is sulphide, or galena, and as a consequence lead poisoning among the miners has disappeared.

Lead Smelting

From lead poisoning—or, as it is sometimes called, *saturnism, plumbism, colica pictonum*, and *colica pictorum*—the British miner, as just stated, is free. The risk to health and life commences with smelting of the ore. People when travelling through lead-mining districts may have noticed here and there a tall, solitary chimney-stack on a hill-top, far removed from other buildings. Such a stack is usually the chimney by which fume generated during the smelting of lead escapes from a lead works which may be situated in the hollow a mile or more away. By means of an underground flue or series of flues 3 to 4 feet high, and made of brick or wood, the smoke and fume from the smelting furnace are conveyed into the open air. The fumes which escape from the stack are dangerous. For a considerable radius round a stack cattle must not graze. Both at home and on the Continent lead manufacturers have had to pay heavy damages to farmers and owners of stock for injury done to the herbage, and for the death of animals which had grazed in the immediate vicinity of the stack. The flues are sometimes of a sufficient height for men to enter so as to remove the dust, which is rich in lead.

However injurious to the surrounding country fumes escaping from lead-smelting works may be, they are a serious menace to the health and life of human beings and animals when the works are near a town. Broken Hill in New South Wales supplies an illustration. The consequences of having allowed dwelling-houses to be built in close proximity to lead-smelting works are there so evident that the experience about to be detailed should be a warning to all prospectors and managers of mining companies about to erect plant on virgin land.

In 1892 there were employed in the Broken Hill Mines and Works 4,445 men. More than half of these worked on the surface. Around the works and within a radius of twelve miles there had grown up within five years a town with a population of 22,500. Five thousand of these people lived in a district called South Town, and were exposed to the fumes escaping day and night from the smelter stacks. Outside of the town the country is a waterless wilderness of salt bush country, almost uninhabited. Here sheep-farming is hazardous. During five years—1888 to 1892—there were 2,132 cases of lead poisoning of human beings, with 11 deaths, at Broken Hill. Owing to the comparatively low temperature at which lead volatilizes, the amount of fume poured forth from the twenty-eight smelters, each of 80 tons capacity, during twenty-four hours, was estimated to be equal to 15 tons weight of the metal used. Some of the fume in a finely attenuated form would float away to a considerable distance, while the remainder, consisting of heavier particles, would become deposited near the stacks. Samples of air tested a short distance from the stacks gave $\frac{1}{20}$ grain of lead per cubic foot, equivalent to 52 grains per 1,000 cubic feet of air. From glycerin-coated plates placed outside one of the hotels in the town there was collected, after eight hours, $3\frac{1}{2}$ grains of lead, with traces of arsenic, per square foot of surface. The fume penetrated into the houses, and it contaminated reservoirs of drinking water to such an extent that in one sample $\frac{1}{4}$ grain of lead per gallon was found, and in another $5\frac{1}{2}$ grains of lead per gallon. Although only eleven fatal cases of acute lead poisoning occurred during the five years alluded to, yet plumbism must have been the cause of much illness of a chronic nature and of an extent difficult to estimate. So bespoiled were the gardens that a child two and a half years old, who had plucked flowers and sucked them, died. On the flowers lead was found. Similarly, milch cows kept within a radius of one to two miles died from lead poisoning. Among cats, dogs, and fowls, the mortality was extremely high. In the bodies of a horse, a dog, and a fowl, lead was found. There are sparrows at Broken Hill, but other birds are rare. Cage-birds can be kept, but only so long as the sand which is placed in the cages is brought some miles away from the town.

Dogs kept at a smelting works in the neighbourhood of Newcastle-upon-Tyne developed a peculiar train of symptoms. They would run round and round, become convulsed, and drop down dead. These circus movements in plumbism are confined to animals. Wild birds which had eaten berries grown in close proximity to lead-smelting works have been picked up dead. These are minor matters compared with the condition of things which, as already stated, existed a few years ago at Broken Hill, where dogs and kittens were with difficulty reared and cage-birds kept. Poultry also died; hens gradually became emaciated and ceased to lay eggs. Women, married and unmarried, suffered from menstrual disorders: abortion and premature births were frequent. At a large lead and zinc smelting works on the Continent, with a frontage to a canal, the manager informed me that the ducks belonging to his workpeople became paralyzed in their limbs, so that they could no longer paddle.

The dangers of lead smelting are now better known than formerly, and employers are taking greater pains to prevent fume escaping. There are economic reasons why they should do so. Since owners of lead-smelting works have increased the length of the flues there have been fewer claims for compensation by farmers than formerly. The bulk of the fume and smoke given off during smelting becomes deposited in the flues, so that only a minimum escapes from the chimney-stacks, and, as these are frequently 100 or 150 feet high, the fume is widely dispersed in an attenuated form by aerial currents.

As the symptoms of lead poisoning in cattle differ from those observed in man, differ, too, between horses and oxen, and are perhaps not well known to the reader, it may be well for me to reproduce here the symptomatology given by Mr. Daniel Parr, veterinary surgeon, in his evidence before the Broken Hill Lead Inquiry Commission. As regards horses, the symptoms in the early stages are loss of appetite, coldness of the limbs and ears, a tucked-up appearance of the barrel, pulse 46 (a slight increase above the normal), rectal temperature 101·5° to 102° F., and the head depressed. At this period of the illness there are no indications of the animals having colic. Later on a grey discharge oozes from the nostrils, there is excessive flow of saliva, and the animals keep champing their jaws. In a still later stage breathing becomes laboured; sometimes it is so difficult that the animal seems as if he were being suffocated, while the exhaled air has an extremely unpleasant odour. There are tremors, perspiration, and restlessness. The animal keeps lying down and rising up as if in pain. By this time the breathing has probably become irregular and more difficult. There is frequent micturition, small quantities of urine being passed every few minutes. The horse keeps walking round and round until he loses control of his movements; he staggers, falls down in convulsions, and in three or four minutes he is dead. At death the temperature may be 106° or 107° F.

In cattle loss of appetite is one of the early symptoms of plumbism. The cow ceases to chew the cud; she stands apart from the herd, becomes restless, the eyes stare and the pupils are dilated. There are—foaming at the mouth; pulse 65, slightly quicker than the normal; a rectal temperature of 103° F., with respiration 25—*i.e.*, 10 above the normal. The muscles of the face and shoulders become the seat of spasmodic twitching. Later on the animal is observed to run round and round, or to rush forward, dashing her head to right or left, as if suffering from an inflammatory affection of the brain. In still later stages the pulse is found to have risen to 80 or more. There are grinding of the teeth, champing of the jaws, a free flow of saliva from the mouth, and indications of abdominal pain. Convulsions supervene, and in these the animal dies. In other instances the breathing becomes laboured, and the cow dies gasping for breath, or she simply lies down, closes her eyes, and dies in coma, death being preceded by a marked fall of the temperature. Parr found that 25 per cent. of the cows which became lead-poisoned died, and that, on account of the expense, the length of time required to be restored to health, and the after-effects of the plumbism—viz., uselessness of the cows as milkers for long afterwards—it was hardly worth while trying to recover them.

Lead can be smelted by various methods, of which two alone need be described. Refractory and dross ores are treated in blast-furnaces, with hearths for removal of the lead and slag at the bottom. Each furnace is fed from above with coke and ore. Air is driven into the lower part of the glowing charge by a strong blast. By the upper part of the furnace smoke and fume escape into one of the main flues, while the molten metal and the slag collect in the hearth and are run off periodically. There is a danger of the flue becoming partially blocked, and of the fumes being reflected upon the workmen, by which may be explained such signs of plumbism, exhibited by smelters, as tremors, paresis or paralysis of the arms and hands, anæmia, and the presence of a blue line on the gums. The furnace-men also run the additional risk of having their health affected by the inhalation of carbon monoxide, which is given off during the incomplete combustion of the fuel. The percentage by volume of carbon monoxide escaping from lead blast-furnaces varies from 3·5 to 10·8. As lead melts at 325° C. (617° F.), its vapour is given off at the ordinary heat of the furnace.

In the Scotch hearth, which is smaller than the English blast-furnace, only galena is treated. The furnace is an open hearth. Upon this workmen place the charge. Two blast-pipes open into the charge from the back of the hearth. As the molten metal rises to the top of the well, or sump, of the hearth, it flows off by a small channel into a collecting pot in front of the furnace. The slag is also run off periodically into water and cooled. Fumes are given off during each of these processes. Usually there is a sufficient amount of lead left in the slag to render it worth while being remelted. Workmen, in breaking up the slag with a hammer, raise clouds of dust, which settles upon the timbers of the smelting shop, the clothes of the workmen, and upon any parcels of food the men may have brought with them. Dr. Edgar Collis,* His Majesty's Medical Inspector of Factories, basing his opinion upon an analysis of the fumes, maintains that in eight hours a man thus employed might inhale 7·38 grains of lead. It is not, of course, maintained that he does inhale this quantity. Of thirty-two blast-furnace men examined, Dr. Collis found in twenty-two a blue line on the gums, and in twelve of the men weakness of the extensor muscles of the hands and fingers.

Cleaning out the flues is a dangerous occupation, on account of the large quantities of lead which the dust contains. Lead fume, as indicated, is the volatile metallic vapour given off from the molten metal in the furnace when brought into contact with atmospheric air, also from the lead itself at extremely high temperatures, such as 1,200° C.; but flue-dust, according to the quality of the lead ore used, is composed of particles of coke or unburnt carbon, silver, arsenic, antimony, reduced globules of metallic lead, lead in the form of oxide and sulphate, also quartz and limestone. Flue-dust is worth recovering, for it may contain as much as

* "Special Report on Dangerous and Injurious Processes."

30 per cent. of metallic lead. Hoffman* found that flue-dust contained as lead 0·8 to 15 per cent. of the weight of the ore charged. In some of the lead works on the Continent of Europe flue-dust contains 16 to 26 per cent. of lead, and as much as 7 per cent. of arsenic. To recover the lead deposited in the dust, workmen enter the flues by manholes placed here and there along their course. In places 2 feet or more of dust may be found deposited in the flues, the removal of which by the shovel raises clouds of dust. To work in such a dusty atmosphere, the men are obliged to wear respirators. It is undesirable that the men should carry on this work for more than two hours without a break. If respirators are not worn, the men suffer from severe headache and feel extremely ill. Serious symptoms develop in men who have worked only a few days in the flues. At a large lead works with which I am familiar, two days were set aside recently for cleaning out the flues. Of thirteen men told off to do so, two of them on the second day suffered from vomiting, diarrhœa, and severe headache, accompanied by a rise of temperature to 102° F. For a few days the men were very ill. Last summer, when in Allendale, I noticed upon a hillside some distance away a

* *Engineering and Mining Journal*, 1906, p. 380.

tall chimney-stack which was showing signs of decay. Dr. Murray of Allendale pointed out to me the smelting works of which it was a part, and which were quite a mile away from the chimney-stack. He gave me the following information: During the winter of 1912-13 he had treated two men for acute plumbism; both of them suffered from a sharp attack of colic. For upwards of twenty years the smelting works had lain idle. It was known that the flues leading to the chimney-stack contained large quantities of deposit rich in lead. The two men referred to had undertaken to recover this, and had entered the flues by manholes. They had only worked two or three days, when they suffered so severely that they were obliged to give up the work. Where flues are closely packed and are on the slope, if the incline is sufficient, it is safer to flush them out with water, and allow the contents to run into reservoirs wherein the material can settle. Lead and its compounds in the form of sludge are less dangerous to the workmen than the dry dust shovelled out of the flues.

Lead as it comes from the furnace is not always pure metal; it may contain silver, gold, antimony, and other adulterants, which have to be removed. The two best-known methods for removing these are the Pattinson and the Parkes processes.

On Tyneside, the home of its introduction, the Pattinson process is mostly in use. The method is based upon the fact that lead crystallizes at a higher temperature than a mixture of lead and silver, so that the crust which forms on the surface, and which contains lead and silver, is skimmed off from time to time for further separation and purification. In Parkes' process zinc is added to the lead. This in the melting-pot forms an alloy of lead, zinc, and silver, which rises to the surface of the molten metal, and can be skimmed off. The further stage of the process consists in separating these. The zinc is drawn off in the form of vapour in a dezincking apparatus, such as the Faber du Four retorting furnace. During the process of dezincking, zinc as well as lead fumes escape, and if the furnace-men inhale these fumes they are liable to suffer from nausea. Men employed in desilvering lead have frequently come under my care on account of plumbism, but on the whole fewer men thus employed have sought my advice than men engaged in some of the other departments in lead works.

Allusion has been made to workmen suffering from nausea as a consequence of inhaling zinc and lead fumes during dezincking of the lead alloy. The smelting of zinc is of itself a frequent source of plumbism, for zinc ores frequently contain lead, *Calamine* ore contains 44 to 60 per cent. of zinc in the form of carbonate, but in *blende* ore, in addition to the zinc which is present in the form of sulphide, there may be lead to the extent of 9·3 to 18 per cent. In making *spelter*, blende ore is roasted in a calcining furnace in order to drive off the sulphur; the residue may contain 1 to 10 per cent. of lead. To the burnt blende, calamine ore, zinc ashes, zinc oxide and chloride obtained from the skimmings of galvanized pots and retort crucibles, are added. Anthracite is also added, and the charge is placed in retorts and exposed to a high temperature. The zinc distils over, and is condensed in a crucible close to the retort. Not only are the workmen exposed to the influence of a high temperature, but they inhale fumes of lead and zinc, and in addition breathe an atmosphere rendered injurious and irritating to the lungs and bronchi by the sulphur dioxide given off at the same time. Considering the small percentage of lead present in some samples of spelter, often not more than 2 per cent., plumbism is extremely frequent among the workmen. Between July 1, 1907, and December 31, 1912, there were, according to Home Office returns, 77 cases of lead poisoning among spelter workers in South Wales alone. German physicians state that spelter workers are old and broken down at forty. To the zinc fumes given off in spelter works are attributed the bronchitis, gastric and intestinal troubles, from which the men suffer, while to the lead fumes are attributed the nervous affections; but where two kinds of metallic fumes are being inhaled simultaneously it is difficult to assign to each its proper share in the causation of symptoms.

Manufacture of Red Lead

Red lead, or minium (Pb_3O_4), is a mixture of PbO with varying amounts of Pb_2O_3. It is prepared by placing pure lead in the open hearth of a reverberating furnace and heating it to a dull redness. During the process the material is raked from time to time. By slow oxidization the lead is converted into lead oxide (PbO). This, known as litharge or massicot—a green-looking substance—becomes yellow or yellowish-red on being washed. After having been washed so as to remove any pieces of unoxidized lead, the massicot is again heated, but at a lower temperature, when, owing to further oxidization, the massicot changes its colour to a bright red, and is called minium, or red lead. If the flue of the furnace is not drawing well, or if the mouth of the furnace is not well hooded, the fumes may be reflected upon the workmen during the oxidizing processes just mentioned.

Clouds of red dust invariably arise during the raking out of the finished product from the furnace.

In the cupelling of lead, a blast of air is blown upon the molten metal in the furnace. The lead thus oxidized is by the force of the blast driven off the surface of the metal into a receiver. In the act of cooling the metal exfoliates. It breaks up into fine crystalline scales like coarse bran, known in the trade as flaked litharge. The process is carried out at extremely high temperatures. When the inner door of the furnace is opened, considerable quantities of fume escape, and, as this cannot all be carried off by the hooded exhaust which leads into the flue, the workmen, unless they stand well back at that particular moment, are likely to be enveloped in fume and to run the risk of inhaling some of it. Between 1900 and 1909 twenty-five men engaged in this work became ill through the effects of lead. The flues from the cupelling furnaces at one of the works which I recently visited are cleaned out once a year. Inside the flues there is a deposit of dust 5 to 6 inches deep. This dust contains 50 per cent. of lead. Some physicians regard the manufacture and use of red lead as only slightly dangerous to the health of workmen. Such is not my experience, nor is it that of Medical Inspector E. R.

Stitt,* of the United States Navy, who reports the admission into the United States Naval Hospital, Canacao, P.I., of three seamen suffering from the encephalopathic type of plumbism, due to inhalation of red lead dust rising from dried surfaces when being chipped preparatory to being repainted. But for the assistance obtained by a microscopical examination of the blood, and the finding therein of punctated erythrocytes, Stitt admits that the diagnosis might have been difficult, although the presence of a blue line on the gums was extremely suggestive of plumbism. One of his patients became insane and had to be removed to an asylum, from which, after a considerable length of time, he was discharged cured. Another of the men had colic; there was a blue line on his gums, and in his blood basophilia. He developed severe epileptiform convulsions. These ceased; by degrees the anæmia which he showed and the tremors he suffered from disappeared. The men had been chipping red paint in the compartments of torpedo boats. Stitt's cases lend support to the opinion I have expressed, that extremely severe forms of plumbism are met with in red lead workers.

Between 1900 and 1912 there occurred in

* *U.S. Naval Medical Bulletin*, April, 1912, p. 161. Washington Government Printing Office.

British red lead factories 134 cases of plumbism.* In one-fourth of the men the symptoms were severe. Sixteen of the men who had been ill had been introduced into red lead works simply as labourers to sweep up the floors. During the sieving, grinding and packing of litharge, clouds of dust rise. Thirteen of the cases above referred to were furnace-men. One patient was a bricklayer who was reconstructing a flaked litharge furnace. He contracted lead poisoning, and died from it. In one of the factories on the Continent a man who was carrying a small barrel of red lead let the barrel fall. It broke. Immediately the workman was enveloped in a cloud of red dust. Symptoms of acute plumbism developed, followed by paralysis of the extensor muscles of the wrists and fingers, which persisted for several months.

Red lead is also manufactured by automatic processes, but, as the machinery is more or less patented, a description of it cannot be given. Suffice it to say that from the time the pig lead is fed into the closed melting-pot at one end, and where it is converted primarily into monoxide, also during its passage onwards through the colouring ovens to the place where it falls as finished red lead into the barrels for packing purposes, the

* "Special Report on Dangerous and Injurious Processes," by Dr. Edgar Collis.

material is never handled by the men. Since there is a minus pressure inside the conduits, no dust is given out at any part of the machinery where the joints have become loose. By this method of manufacture fewer workmen are required, the atmosphere is clearer, and the men run no risk except at the hopper where the red lead falls into the barrels. When this part of the machinery is effectively screened, the manufacture of red lead becomes an industry remarkably free from many of the risks hitherto incidental to it.

Manufacture of White Lead, or Lead Carbonate

Notwithstanding the opposition in many quarters to the use of white lead, there is still a great demand, if not an increasing one, for the pigment. It is estimated that, in 1910, 58,000 tons of white lead were manufactured in this country, and that 14,500 tons were imported from abroad. In Great Britain this particular department of the industry gives employment to 2,500 men, while the capital invested for manufacturing purposes cannot be far short of £1,500,000. In the United States of America the manufacture of white lead was begun in 1777. The annual production of white lead in the States is 100,000 tons.

By the term *white* lead is meant the carbonate. Lead sulphate is also a white pigment, but commercially it is always known by its chemical designation. Two of the best-known methods of making white lead are (1) the Dutch process, and (2) the chamber process. In the Dutch process thin perforated plates of metallic lead, called "wickets" or "grids," are taken to a stack, or corroding house, a large quadrilateral space, subsequently to be spoken of as the "blue bed," one side of which opens into a main passage. There are usually several stacks placed side by side in a row. On an average the stacks are 20 feet high and 16 by 13 feet. Upon the floor of the stack bark from a tanyard is strewn to the depth of 2 to 3 inches. On the bark are placed rows of wide-mouthed earthenware jars, 6 to 7 inches high, half filled with a 2 to 3 per cent. solution of acetic acid. The lead plates, known as "wickets" or "grids," are placed sideways on the top of the open jars. The lead used must be pretty pure, for the presence of silver, bismuth and copper are, from the white lead manufacturer's point of view, impurities, and interfere with the results. Upon the wickets is placed a layer of wooden planks. Bark is strewn upon the planks, and on the tan another series of jars containing acetic acid, and supporting metallic plates, is laid.

Thus, by a series of alternating layers, called in Scotland "heats," the stack becomes built up from bottom to top, care being taken, as the blue bed is being reared and as each layer is completed, to place planks across the open entrance, so as to confine the contents. The making up of a blue bed may be done by women. Home Office regulations allow of this. It does not require skilled labour. An unoccupied space of a few feet is left at the top of the stack, and at the sides pipes are inserted for the purposes of ventilation, the removal of vapour, and the prevention of too high a temperature. In a stack there are usually twelve layers of tan, jars, and lead plates, but in some works there are fifteen. Some managers believe that better results are obtained where there are only twelve rather than fifteen layers. If the layers are too many, less of the lead in the mid-zone of the stack is corroded.

Although there is a considerable amount of handling of the wickets by the women who make up the blue bed, the work is not regarded as injurious. I have, however, known of women suffering from colic when thus employed. When the blue bed is fully made up, the outer doors are closed, and the stack is left undisturbed for 100 to 130 days. In the course of a few days the temperature inside the stack rises. It may reach

80° C., but manufacturers prefer a lower temperature—50° to 60° C.—and in order to secure this they frequently add, when making up the stack, old tan to the new, so as to prevent too rapid fermentation. Thompson is of the opinion * that the fermentation, or decomposition, which takes place within the stack is the result of the activity of bacteria within the tan, and that, as the process continues, the part played in the initial stages by micro-organisms is replaced by combustion. At the end of three months, when the stack is opened, it is known no longer as a "blue," but as a "white" bed. Into it women are not allowed to enter, for the stripping of the white lead and the removal of the uncorroded lead are dangerous. During the three months the stack was closed fermentation of the bark had been going on, attended by a rise of temperature. The acetic acid had vaporized, and had attacked the metallic lead, converting it into lead acetate; but, as carbonic acid was at the same time given off from the tan, a double chemical action had taken place, whereby the lead acetate was converted into hydroxycarbonate. White lead is a basic compound containing two molecules of normal carbonate of lead in combination with one molecule of lead hydrate or lead oxide, and it has the formula $2PbCO_3Pb(OH)_2$. √

* *Journal of Society of Chemical Industry*, 1909, p. 28, etc

It has been taught that white lead is a mechanical mixture of hydrate and carbonate of lead; that the hydrated portion gives the spreading power to paints made from the pigment, and that the carbonate gives the opacity, but on this point recent opinions differ. Pure carbonate of lead is useless as a pigment. It is owing to its peculiar composition and the varying size of its molecules that it combines so well with oil "as to confer upon it as a paint that smooth working quality in the brush which enables painters readily to produce a smooth and uniform coat, rendering it water-shedding and resistant to decay" (Noel Heaton).

Corrosion or conversion of the metallic lead into carbonate is never quite complete. There is always a certain amount of the metal left. Corrosion is said to be good when 70 to 75 per cent. of the metallic lead has been converted into the carbonate. From every hundredweight of metallic lead used, 50 to 78 pounds of white lead are obtained. There is usually a trace of acetate of lead left between the metal and the superjacent carbonate. Occasionally the white lead shows a delicate pink colour from the tan. Manufacturers prefer a hard—that is, a crisp—corrosion to a soft one.

In most of the large white-lead-producing countries, men only are allowed to strip or empty a white bed; for it is dusty work, calling for water-spraying and for the wearing of respirators on the part of the men. The hands of the workmen become covered with white lead; the fine powder adheres to the skin, particularly to the sides of the nails; it also penetrates under the free end of the nails. The dust, too, lodges between the hairs of the beard and the moustache. From the respirators worn by the men considerable quantities of lead can be recovered. Emptying of a white bed is hard work. The material is carried away in wooden boxes by the men, or swung out of the stacks by means of machinery, and conveyed to the wash-tubs to be crushed between wet rollers and washed, so as to have any lead acetate removed. The washed white lead forms a pulp. This, when thoroughly sedimented and dried in an oven, is sold as white lead, or it may be straightway mixed with linseed-oil and made into paint. One of the most dangerous operations in the manufacture of white lead is emptying the ovens or stoves. Formerly emptying of the stoves by hand labour gave rise to more cases of serious plumbism than any other process. By substituting machine for hand labour, much sickness has been averted. The other method of dealing with the sedimented white lead is, as stated, to treat it at once with linseed-oil by the method known in the trade as "pulping." When I was a member of the Potteries Commission of the Home Office, my attention was drawn to this method of treating the washed white lead by M. Besançon, during my visit to the white lead works of MM. Besançon, Expert et Cie., Paris. After having been washed and the excess of water removed by filter presses, the white lead is passed through a series of rollers, during which linseed-oil is constantly being added. By degrees the oil replaces the water in the pulp, so that from the end roller a practically finished paint escapes, yet one not quite free from water. The remaining water is extracted by placing the material in a closed iron cylinder heated by a steam jacket and kept under a reduced pressure. By this means nearly all the water is removed, only part of a decimal point being left. Struck by the cleanliness of M. Besançon's factory, the absence of dust, and the freedom of the men from lead poisoning, I reported the circumstance to the Home Secretary (then Sir Matthew White Ridley), who at once circularized the British manufacturers, with the result that the firms which have adopted the process mostly sell the white lead in the form of paint; but, as by this method of manufacture drying chambers or ovens have been abolished, the factories have become freer from lead poisoning.

In the chamber process longer and thinner sheets of metallic lead are used than in the Dutch process. These are suspended over a series of rails in a chamber, and the door is hermetically closed. Hot acetic acid vapour and carbon dioxide obtained from burning coke are driven into the chamber by pipes from below. Changes of a chemical nature, similar to those described as occurring in the blue bed in the Dutch process, are induced; but in the chamber process corrosion is more rapid, for in fifty to sixty days the metal is converted into white lead, the temperature of the chamber having been kept pretty regularly at about 60° C. Before opening out the chamber, steam is injected into it to moisten the material and to render it less dusty to the men when removing it. Before the men enter the chamber the door is kept open for some hours, so as to allow the temperature to fall.

In this country there has been an outcry against the use of white lead, which is not lessening, especially since France has passed a law forbidding the use of lead for decorative purposes, and which comes into force at an early date (1915). Considered from an historical point of view, it is hardly likely that an industry which has been in existence for more than 2,000 years will readily disappear. Trade customs die hard. Lead compounds have such a varied and extensive field of application that it will be difficult to find substitutes for them in some of the arts and manufactures. From its antiquity alone the trade is entitled to some consideration, even while we admit that lead and its compounds are dangerous. Something of the age of the industry may be learned from an address given by C. A. Klein * to the Paint and Varnish Society, London. Cerussa as a cosmetic is alluded to by Xenophon (430-355 B.C.). An earthenware box belonging to this period was recently unearthed, and found to contain a mixture of white lead and whiting. This powder, like that used by the ladies of Florence in the fourteenth century, had been resorted to for the purpose of heightening beauty—a practice apparently not without danger, since it drew from Cennino Cennini a warning homily. The cerussa referred to by Xenophon was probably a powder obtained by grinding a native lead carbonate ore, such as is still known as cerussite. According to Vitruvius (100 B.C.), the Rhodians made white lead by pouring vinegar into vessels over vine twigs contained therein, and on the twigs they placed metallic lead. The vessels were covered over to prevent evaporation. On these being opened after

* *Oil and Colour Trades Journal*, December 6 and 13, 1913, p. 1973, etc.

a specified time, the lead was found to have become converted into cerussa. The Rhodian product was regarded as an article of great commercial value. Considering the method of its preparation, it would at first appear as if the substance obtained was a basic acetate of lead, and not a carbonate; but basic acetate of lead when exposed to atmospheric air becomes gradually converted into carbonate. A certain amount of carbonic acid would, however, probably be present, since, during decomposition of the twigs upon which the lead was laid, also in consequence of decomposition of the vinegrated grape pulp likely to occur as well, carbonic acid would be evolved, and would assist in the conversion of metallic lead into carbonate. This simple method of converting metallic lead into carbonate by the action of acetic acid and of carbonic acid evolved during fermentation of the residuum of pressed grapes is still followed at Klagenfurth, in Carinthia. Centuries ago the heat-producing agents required for the conversion of metallic lead into carbonate were manure and other decaying organic material. Not only is heat evolved from these, but carbonic acid as well. In order to increase for corroding purposes the carbonic acid given off from manure, the Dutch in 1622 added wine-lees and chalk to vinegar. They also improved the stack process then in existence, and became active competitors with the Venetians. England at this period was awaking.

In 1662 the first patent was granted to Eland, and in 1749 Creed obtained a patent to manufacture white lead by what is now known as the chamber process. At this date not only was Newcastle-upon-Tyne a recognized seat of the trade, but it was here that was introduced the use of spent tan bark in the corroding stacks, and which has been ever since an important element in the manufacture of white lead by the Dutch process. The patent for the use of tan bark was granted to Richard Fishwick, then a partner in the now well-known firm of Messrs. Walker, Parker and Co., Newcastle-upon-Tyne. As thus modified, the Dutch process has still many adherents. Opinions differ as to the relative values of white lead manufactured by the Dutch method (fourteen weeks) and that by the chamber process (eight weeks). Regarded from the hygienic point of view, the chamber process is cleaner, time is saved in the corrosion, more of the metal is said to be corroded, and there is a saving of labour in filling and emptying the chambers. Mr. Noel Heaton * considers chamber white lead to be brighter in colour, probably owing to the absence of tan

* *Journal of the Royal Society of Arts*, March 14, 1913.

influence, to be finer in the grain and more uniform, but many master-painters with whom I have discussed the question prefer white lead made by the Dutch process. That the material thus produced must possess the good qualities ascribed by them to it is shown by the fact that the Dutch process still remains in many factories the sole method of making white lead. Nay, more than this: of the 275,000 tons of white lead produced by various processes, the approximate quantities given by Klein are—

	Tons.
Stack, *i.e.*, Dutch, process	180,000
Chamber	45,000
Miscellaneous	50,000

In Great Britain it is estimated that 70 per cent. of the white lead is manufactured by the Dutch process, and in the United States 80 per cent. Estimating the total production of white lead in the world to be 275,000 tons, it is interesting to see how the various countries contribute to it:

	English Tons Dry.
United States	120,000
Great Britain	55,000
Germany	36,500
France	20,000
Belgium	15,000
Russia	14,500
Italy	4,500
Holland	2,500
Spain	2,500
Canada	2,500

Statistics of Industrial Lead Poisoning

In the Annual Report of the Chief Inspector of Factories, 1912, Dr. T. M. Legge has presented in tabular form the number of cases of lead poisoning notified to the Home Office for thirteen years—1900 to 1912 inclusive. Compulsory notification of cases of industrial lead poisoning has proved of invaluable service, not only in supplying information to the Home Office of the presence of plumbism in a particular factory, but of drawing attention to the possible existence of defects, structural or otherwise, and of the necessity of immediately remedying them. In white lead factories alone the deaths were as follows:

Year.	Cases.	Deaths.
1900	358	6
1901	189	7
1902	143	1
1903	109	2
1904	116	2
1905	90	0
1906	108	7
1907	71	0
1908	79	3
1909	32	2
1910	34	1
1911	41	2
1912	23	0
Total	1,393	33

That is, of those suffering from plumbism 2·2 per cent. died.

As showing the difference in the mortality rates of lead poisoning due to working in white lead factories and lead poisoning following upon working in other trades in which white lead is used, the following table, taken from the same source, will not be out of place:

All Cases of Industrial Lead Poisoning notified to Home Office, with Number of Deaths.

Year.	Cases.	Deaths.
1900	1,058	38
1901	863	34
1902	629	14
1903	614	19
1904	597	26
1905	592	23
1906	632	33
1907	578	26
1908	646	32
1909	553	30
1910	505	38
1911	669	37
1912	587	44
Total	8,523	394

Taking the total cases of lead poisoning, the fatal cases are 4·5 per cent.; but if we deduct the cases and deaths of lead workers, the mortality rate is 5·06, as against the 2·2 per cent. fatal cases in white lead workers. This difference in the mortality rate is not without significance; it suggests that it is among white lead workers that the regulations issued and enforced by the Home Office have been most productive of good.

The 8,523 cases of lead poisoning occurred among persons employed in eighteen industries. The number of cases notified in 1900 and 1901 were respectively 1,058 and 863, and for 1911 and 1912 they were 669 and 587. While the number of cases notified has declined, the same cannot be said of the fatalities. In 1900 and 1901 the fatal cases were 38 and 34 respectively, but in 1911 and 1912, although, according to the tables, fewer cases were reported, there were 37 and 44 deaths respectively.

Control of dust in industrial occupations in which white lead and lead compounds are manufactured or handled has done much to bring about a reduction in the number of cases of plumbism. It is Dr. Legge's opinion that, if the amount of lead present in the air breathed is less than 5 milligrammes per 10 cubic metres of air, saturnine encephalopathy and paralysis will not occur. Taking ten hours as the period of an ordinary working day, it is estimated that during that time 4½ cubic metres of air pass in and out of the lungs. The inhalation of 2 milligrammes of lead daily in the form of fume or dust would in the course of a year set up lead poisoning. If such an amount of lead reached the lung in each working day, something like 600 milligrammes, or 10 grains, of lead might be absorbed in the course of one year; but there is no evidence to support this mathematical contention. Dr. Ludwig Teleky of Vienna informs us that a daily dose of a little more than 1 milligramme of lead taken for several months will cause plumbism, and that a daily dose of 10 milligrammes will cause symptoms of severe saturnine intoxication in a very short time. We can, of course, never be quite sure of the quantity of lead which reaches the lungs and is retained there in men who are working in, and breathing, an atmosphere laden with lead dust, for much of the dust is caught in the nasopharynx and is swallowed, or it is trapped in the upper respiratory passages and does not reach the lungs at all.

The results of the notification of lead poisoning are extremely interesting as showing the changes which have taken place both in the personnel of the workers and in the hygiene of certain trades. In 1900 the largest number of cases of plumbism occurred in the white lead trade—viz., 358, with 6 deaths; in earthenware and pottery there were 200 cases reported and 8 deaths. In 1912 the manufacture of white lead no longer occupies the unenviable first place on the list of trades in which plumbism occurs. This position is taken by the earthenware and pottery industry, with 80 cases and 14 deaths, and closely upon it comes coach-building, with 84 cases and 7 deaths, as against 70 cases with 5 deaths for 1900, or an increase of 1·2 per cent. Smelting of metals, which in 1900 gave 34 cases with 1 death, gave in 1912 56 cases with 7 deaths; printing, with 18 cases and 2 deaths in 1900, furnished in 1912 37 cases without a death. On the other hand, the manufacture of white lead, which was formerly regarded as one of the most dangerous of all the lead industries, with its 358 cases and 6 deaths in 1900, gave in 1912, with no deaths recorded against it, 23 cases. These figures refer only to plumbism occurring in persons mostly at work; they convey no intimation of the number of deaths caused by kidney and other internal diseases, and which are consequences of chronic plumbism in persons many of whom had years previously worked in lead factories.

The undesirable position occupied by coach and house painting on the list of occupations in which plumbism occurs is not confined to Great Britain alone. On the Continent the same event is taking place. The rapid rise of the motor-car industry is largely responsible for the increase in the number of cases notified. Lead poisoning is more prevalent among house painters than it ought to be. Painters when at work are not always strictly observant of details of personal hygiene. The practice of holding the brush between the teeth, of holding putty, which is a lead product, in the palm of the hand, of not always having the opportunity of washing before eating, or of misusing the opportunity when it exists, predisposes them to plumbism. Inhalation of dust given off during the sand-papering of dried painted surfaces, also of the fumes given off during the burning off of old paint, are sources of lead poisoning. The clothes worn by the men become stained with paint. I have treated women who had washed the overalls of their menfolk, who were house painters, for double wrist-drop, and in the water removed from the wash-tubs I found large quantities of lead. In these cases the poison either was absorbed through the skin by friction during the act of washing, was inhaled as dust on shaking the clothes before washing them, or was inhaled as fine particles in the steam.

People have suffered severely in health through having slept in newly-painted rooms. There is an account in the textbooks of an outbreak of lead colic among the crew of a freshly-painted French man-of-war. All persons are not equally susceptible to the harmful emanations from painted surfaces. Some people cannot be exposed to the odour of paint without experiencing headache followed by retching and vomiting.

It would be interesting to know precisely what are the harmful emanations given off from a painted surface. Professor C. Baly, of Liverpool, found, on spectroscopic examination of the air drawn from over newly - painted surfaces, evidence of the presence of lead; but a further series of experiments led him to alter this statement, and to attribute the influence for harm to "unsaturated aldehydes," or the volatile emanations given off by certain lead paints. Taking the two substances, white lead and sulphate of lead, and mixing them separately with linseed-oil in exactly the same manner, he noticed that there was a difference in the odour evolved. When the emanations from the white lead surface were examined by the spectroscope, they were found to contain a substance which absorbed ultraviolet radiations given off at a temperature of 60° to 65° C. Sulphate of lead mixed with linseed-oil did not give exactly the same results as the carbonate, while dry white lead gave a negative result. It is maintained that if, in the emanations there is present a sufficiency of "unsaturated aldehyde," not only is the odour nauseating, but it causes a sense of tiredness attended by headache and followed by diarrhœa, symptoms suggestive of some form of intoxication. Baly did not find evidence of lead in the emanations in the second series of experiments, but of "unsaturated aldehydes," or substances given off more readily by the hydroxide of lead than by the carbonate, also by other oxides of lead and binoxide of manganese. At ordinary temperatures the volatile substance is given off in the following proportions:

Zinc white and basic sulphate of lead ...	1
White lead	15
Lead hydroxide	25

The symptoms alluded to as occurring in persons who inhale the emanations from freshly-painted surfaces are therefore by Baly believed to be caused by aldehyde compounds, and not by lead. He is of the opinion that the cause for harm would greatly disappear if zinc white or basic sulphate of lead was used instead of white lead or minium, but in all cases it is necessary to reduce to the smallest quantity possible the amount of "dryer" employed, for the addition of turpentine to the paint increases the amount of aldehyde. Baly thinks that the rapidity with which the symptoms develop is rather, but not absolutely, against lead poisoning.

Professor H. E. Armstrong and Mr. C. A. Klein* take the view that the production of

* Society of Chemical Industry, "The Behaviour of Paint under the Conditions of Practice," February 3, 1913.

volatile products is not peculiar to white lead, but is common to all drying agents. According to them, no lead is found in the vapour given off by paints during drying. The vapours consist of "volatile thinners" and oxidation products of the oil which are common to all paints. The products of oil-drying are absolutely harmless, but the vapours arising from the turpentine are responsible, they believe, for the toxic effects observed in persons who have slept in recently-painted rooms. The effects would thus be in no way due to lead, since they might be produced by all paints which contain turpentine.

As to what the emanations from freshly-painted surfaces really are, it is apparent that the last word has not been said. Chemical experiment and medical experience can alone solve the problem. Air withdrawn from a bell-jar in which metal boxes recently painted with white lead had been placed, when passed through a 10 per cent. solution of sulphuric acid, was found to contain lead. There may be other harmful substances present in paint than lead. Messrs. Heim and Hebert exposed moulds, especially *Penicilium glaucum*, to air in closed bell-jars under the following conditions: (*a*) Air alone; (*b*) air which might have been infected with lead; and (*c*) air in contact with fresh paint. In (*a*) the moulds developed by the third day;

in (*b*) shortly after the third day; while in (*c*) not only was there considerable delay in development, but the colonies which developed were few. Another mould, *Aspergillus niger*, had its growth similarly arrested. These experiments do not prove that lead was the harmful agent. Trillat did not find that white lead or oil, singly or combined, checked vegetable growth, but that freshly-mixed paint containing turpentine in addition had the power of doing so. A guinea-pig exposed in a bell-jar to air drawn over a newly-painted surface died within eighteen hours from acute congestion of the lungs, but the death was probably the result of breathing terebinthinated vapour; for in one of my own experiments a mouse which had only been once for two hours in a large bell-jar, through which turpentine vapour was passed, died three days afterwards from acute pulmonary congestion and minute hæmorrhages. To some persons turpentine is a rank poison; it causes headache and vomiting. And yet turpentine alone can hardly be the cause of all the symptoms observed in persons who have been sleeping or living in newly-painted rooms, for Trillat found that, if the paint was made with zinc white instead of lead carbonate, even although it contained the same amount of turpentine, no symptoms developed. This would suggest that there is something of a harmful nature developed when white lead, linseed-oil, and turpentine, are mixed together. Trillat's observations await confirmation. I have had to treat men who, after mixing white lead with certain oils, suffered severely from headache, retching, and vomiting, and not when other oils were used, but the symptoms developed were not those of lead poisoning. They suggested poisoning of another type than that caused by lead. I have kept animals in hutches exposed to vapours given off from newly-painted surfaces for weeks without symptoms developing; and yet I recently had to treat a London medical practitioner who had lived at home during the few weeks the interior of his house was being painted, and who had not only suffered from severe colic, but developed albuminuria and profound anæmia. As lead was found in his urine, the diagnosis was plumbism, but a doubtful point subsequently arose as to the source of the plumbism, for when ill the patient had gone to a small Yorkshire town the drinking water of which had been contaminated by lead.

Henry A. Gardner,* assistant director, the Institute of Industrial Research, Washington, U.S.A.,

* "The Toxic and Antiseptic Properties of Paints," Educational Bureau, Paint Manufacturers' Association of the United States, Bulletin 41, 1914.

finds, after an extended research into the character of the volatile vapours given off by various paint materials, that, as paint vapours do not contain metallic ingredients, they cannot be held accountable for lead poisoning. The most important outcome of his tests is the discovery of carbon monoxide in the vapours of drying paints. To inhalation of this gas Gardner attributes the anæmia from which painters suffer. In the drying of thin layers of linseed-oil there is an absorption of oxygen, accompanied by the evolution of carbon dioxide and carbon monoxide. A small quantity of formic acid is also given off. The amount and character of the volatile substances are affected by the type of pigment used. Aldehydic substances are also given off from drying oil paints, which have a bactericidal effect upon pathogenic bacteria, a point to which I will allude farther on. Gardner's tests were carried out in a large linoleum works where tons of linseed-oil were being used. His views are extremely interesting, and give material for reflection, for as medical men we wish to know more than we do of the harmful effects upon workmen of the repeated inhalation of minute quantities of carbon monoxide. "Symptoms such as sallow complexion, general lassitude, emaciation, and inco-ordination, caused by the inhalation of carbon monoxide over long periods of time, might be mistaken for symptoms of lead poisoning." It is to be remembered that it is, with painters, not so much the putting on of fresh paint which is the cause of symptoms, as the chipping off of old and dried paints. Gardner's researches have struck a new line, and on that account are interesting and valuable.

They seemed to me to be so valuable that I exposed a guinea-pig to the vapour given off by a leadless paint, and another guinea-pig to vapour from a lead paint. Although at the end of five hours the first animal seemed uncomfortable, shortly after it was removed from the bell-jar, and placed on the laboratory floor, it was soon all right again. The experiment was repeated for three days—six hours' exposure each day—without any bad effects. The other animal, which was exposed to the vapours from lead paint, at the end of three hours seemed uncomfortable. Its movements were inco-ordinated, and there was marked polyuria. The animal staggered if it attempted to walk, or it kept rolling over and over, trying to regain its feet. Next day the animal was found dead. The signs enumerated were not those of lead poisoning. On examining the blood removed from the heart, carbon monoxide was found by one of my colleagues and myself.

There appeared recently in the daily papers the details of an inquiry into the death of an infant, two years old, in the workhouse at Bath. This occurred during the painting of a corridor, which continued for five days. The finding was "Death from lead poisoning." Two other children and one woman had also been ill. The paint was said to contain 10 pounds of white lead in 12 pounds' weight of paint. The corridors had frequently been painted before without any mishap. There is no evidence that in this case death was due to plumbism. Much more likely it was the result of inhalation of vapours given off during drying of the oil. Linseed-oil in drying, as we have already seen, increases in weight, owing to absorption of oxygen. Various decomposition products are formed, amongst which may be mentioned formic acid, acetic acid, carbon dioxide, carbon monoxide, and aldehydes, but as to which of these is the agent for harm, it is impossible to say. All we can say is that carbon monoxide is possible.

Some of the dryers which are added to paints are more harmful than others. In my laboratory a rat exposed for a few hours daily to the vapour given off from a spirit containing benzole experienced no inconvenience, but exposure of the animal under similar conditions to a spirit containing turpentine, used by a local firm of paint manufacturers for mixing paints killed it, death being due to pulmonary congestion. Turpentine is a reducing agent: it absorbs oxygen so as to form with it a resinous body; this combination is hastened in the presence of lead oxide. According to Von Jaksch,* the symptoms complained of by men after working in an atmosphere impregnated with turpentine are headache, dizziness, dry throat, cough, bronchitis, strangury, and the presence of blood in the urine. As the kidneys are the main organs by which turpentine is eliminated from the body, pain in the back is frequently complained of. The men become nervous and excited, their gait is staggering. Drs. E. R. Hayhurst and T. E. Flynn, along with Mr. R. H. Nicolls,† made a detailed examination of sixty-two painters and varnishers in Chicago. All but fifteen of the men had worked more than ten years. Nearly all of them stated that after working with turpentine they became drowsy, suffered from headache, had nausea, vomiting, loss of appetite, and dizziness. Minor forms of bladder trouble, of inflammation of the eyes and of the skin, were common. In fourteen of the men —*i.e.*, 31·8 per cent.—there were evidences of

* "Die Vergiftungen," p. 405. Wien and Leipzig, 1910.

† Report of Commission on Occupational Diseases, State of Illinois, 1911.

organic disease of the kidneys, while an equal number of them complained of their throat and lungs.

Dr. Alice Hamilton is of the opinion that, as ship-painters have to carry on their work in confined spaces, symptoms of turpentine poisoning occur in them more frequently than in house-painters. Setting aside the classic form of wrist-drop and colic, there is little doubt that the acute illness house-painters suffer from is not always plumbism, but is the result of the inhalation of vapours given off by the materials with which the pigments are mixed. The exact nature of these vapours is, as already stated, not known. During an examination of 100 painters in Chicago, February to April, 1913, in response to questions addressed to them by Dr. Emery R. Hayhurst, as to what the men themselves considered the most unhealthy part of their occupation, practically all of them stated that they were rendered temporarily sick by the vapours evolved from turpentine and benzine. Much of this type of toxæmia from which the men suffer is the result of the increasing use of quickly-drying paints. In addition to turpentine, petroleum spirit and benzine are being used. In my own experiments I have not found benzine spirit so quickly harmful to animals as turpentine. This may have been due to the small percentage of benzine present. Benzine causes sleepiness. Men working with paint containing it complain of headache, noises in the ears, and dizziness ; they stagger as if intoxicated, they have lapses of memory and hallucinations of sight and hearing. A painter thus poisoned by benzine vapour feels like a man who has been intoxicated overnight by alcohol. Where men are working in the close spaces of ships, and no air is circulating, the symptoms of poisoning may become alarming. Currents of air are intentionally excluded because drying takes place more quickly. The men under these circumstances may be found by their mates in a state of collapse or of unconsciousness ; they may be breathing heavily, and their pulse rapid. They should be carried into the open air at once. Prolonged exposure to vapour containing minute quantities of these varieties of petroleum spirit is followed by impaired digestion, tremor, nervousness, muscular weakness, chronic bronchitis, and defective memory, symptoms indicating that the poisonous vapours have a special affinity for nerve tissue. Von Jaksch found certain forms of chronic skin troubles in painters using pigment mixed with benzine.

Clearly, therefore, turpentine, petroleum spirit, and benzine, when used as dryers of paints, give rise, each of them, to a series of symptoms *sui* *generis.* Benzole, which is occasionally used for removing paint and varnish, is a volatile liquid containing several hydrocarbons. Although it contains only 40 per cent. of benzine, it is more volatile and more dangerous than benzine (Von Jaksch). Inhalation of benzole or benzine vapour may, under certain circumstances, be rapidly fatal. Beinhaaer found that it caused disintegration of the red blood-corpuscles, hæmorrhages upon mucous membranes and into various organs which presented signs of parenchymatous degeneration.* In acute benzole poisoning the symptoms are headache, dizziness, a flushed face followed by cyanosis, nervous excitement not unlike that caused by alcohol, also hallucinations, delirium, and coma. In chronic cases of benzole or benzine poisoning the gums and lips become inflamed and ulcerated; the condition of the gums recalls that observed in scurvy.

The peculiar train of symptoms observed in persons who have been exposed to emanations from newly-painted surfaces, and which are not always those of lead poisoning, must be my excuse for this rather long digression. Reverting to the subject of plumbism in house-painters, the men who suffer most are those who mix the colours,

* "Hygiene of the Painters' Trade," *Bulletin of the U.S. Bureau of Labour Statistics*, Dr. Alice Hamilton, May 13, 1913.

also those who use them. House-painters probably become ill less frequently through inhaling vapour than from breathing the dust given off during sand-papering of flat surfaces or during the smoothing of these with pumice-stone. In 1907, during a Government inquiry in Austria, 208 painters were examined in a particular district. Fifty of the men gave a history of lead poisoning; of these, 23 stated that their first attack of plumbism developed after dry sand-papering lead-painted surfaces. Of 100 painters examined by E. R. Hayhurst in Chicago, 99 complained of the lead paint dust given off during sand-papering, and of these men 27 had had genuine attacks of plumbism.

The use of water with pumice-stone allays dust. Moistening the sand-paper with oil in no way interferes with the results from a decorative, and is of assistance from a health, point of view. Old painted surfaces have to be prepared for fresh coatings by being burnt off, by chipping and sand-papering. The flame from a gasoline lamp causes the paint to shrivel and to curl up. Men when doing this particular kind of work have complained of feeling ill, but it is a question as to how far the symptoms are those of plumbism. The odours evolved during the burning off of old paint are anything but agreeable. They cause headache and sickness. Does the stithe which is given off contain lead? Professor Julius Stieglitz,* of the Chemical Department of the University of Chicago, hardly thinks it is possible for lead to be given off by the painted surface during the short time the gasoline flame is in contact with it. The temperature is not high enough. If, on the other hand, the flame is allowed to play long enough upon the painted surface, and smoke should rise, the smoke is capable of carrying away mechanically lead particles with it. Such symptoms as headache, retching, and a feeling of malaise, therefore, would probably be under ordinary conditions the result of the overheated oil of the old paint rather than the result of lead intoxication; but whether it be this or not, it is desirable that after every hour or two of work done the burnt-off paint which has fallen to the ground should be swept, gathered, and removed, before it has had time to become dried and pulverized.

House-painters employed on internal decorative work are, when compared with outside men, more exposed to the vapours from recently-painted surfaces, also to the dust from dried paint. More sand-papering is done inside than outside our houses. There is a growing demand in Great

* *Bulletin of the U.S. Bureau of Labour Statistics*, 1913, p. 35.

Britain for zinc white and lithopone for internal decoration. In the United States the painting of signboards is a special trade. It is highly skilled labour. Young men are apprenticed to the trade for four years. During the last fifteen years a change has been creeping over this trade. "Signboards" are now prepared in the painters' shops. Lead is one of the commonest pigments used both on iron and wood. Although the occupation is not so healthy as it was when all the work was carried on out of doors, yet, since sand-papering is not required to any extent, the work is much healthier than that of a house-painter.

Ship-painting, so far as the decoration of saloons and cabins is concerned, is highly skilled work. As in coach-painting, several coats of paint have to be applied. The paint frequently contains lead and turpentine, and when the surface is dry it has to be sand-papered. Apart from the use of rapidly-drying spirit paints, there is little danger to men when painting the outside of a ship, for the work is carried on in the open air, so that vapours are readily dispersed. It is the inside work which is trying to the men, for when the final coats are reached the paint frequently contains lead and zinc white in equal parts, with turpentine only and no linseed-oil. This is the part of the work the men object to ; but, as stated earlier, the symptoms are probably due more to turpentine than to lead, judging from the strangury, hæmaturia, and pain in the back, complained of. The remarks apropos of the finer decorative work inside houses and ships apply equally to the painting of railway carriages, coaches, and automobiles. Painters of agricultural implements occasionally suffer from plumbism when the red paint contains lead, but, as much of the work is carried on in the open air, there is less risk to the men than in indoor painting.

Lead Paints and Leadless Paints

We can hardly avoid considering the question of lead *versus* leadless paints. Any reliable opinion upon the relative commercial and decorative values of white lead paint and paint made with zinc oxide can only be furnished by technical chemists, colour manufacturers, master-decorators, and practical house and ship painters. Among these experts there is, unfortunately, a great variety of opinion. Their divergent views render it difficult for other people to express an opinion. The question as to whether, from a purely decorative point of view, the use of white lead paints should be entirely disallowed is a matter in regard to which in this country no satisfactory decision has as yet been arrived at. It is therefore one concerning which, before any legislation is attempted, a body of experts should be invited by the British Government to carry out a series of experiments in different parts of the country, and to report to the Home Office. There is no need for undue haste in the matter. France has passed a law totally prohibiting the use of lead paints after 1915, but doubts have been expressed both in France and in other countries as to the wisdom of the step. I have already alluded to the antiquity of the white lead industry, and to the difficulty of abolishing old trade customs. These remarks apply here equally well. Total prohibition of the use of lead paints was tried in Switzerland in 1904, and abandoned as being impracticable. The White Lead Commission of the Netherlands reported that zinc white paints withstand the action of sulphuretted hydrogen better than white lead paints, but that they do not withstand the action of the sulphurous acid present in the atmosphere so well as paints made with white lead—that is to say, for internal decoration zinc white is as good as, if not better than, white lead, but that for outside work white lead is superior. Since 1909 Belgium has prohibited the sale and use of dry white lead, but she allows the sale of this material mixed and ground in oil. Germany permits the sale of white lead paint already mixed and ready for use. Austria prohibits the use of white lead for the interior of houses. No uniform international attitude has as yet been assumed in regard to this important question. It is one to which the International Association of Labour Legislation is giving attention.

There is nothing to support the statement which is current in some quarters, that British house-painters are prejudiced in favour of lead paints. Knowing the danger incidental to their use, they have nothing to gain by using them to the exclusion of others. Zinc oxide and lithopone, the latter a compound of zinc sulphide and barium sulphate, have been recommended as substitutes for lead carbonate. As pigments these undoubtedly possess valuable properties. The high degree of opacity owned by white lead, the readiness with which it obliterates uneven surfaces and produces a dense white effect with very little material, render it difficult for it to be replaced by substitutes. For external decoration lead carbonate stands exposure to the weather well. There is less division of opinion in regard to zinc white giving equally as good results as lead carbonate in internal work. Noel Heaton maintains that zinc white has neither the fineness nor the density of white lead, nor is there that peculiar influence exerted upon oil by it whereby the absorption of oxygen is increased and the paint caused to dry quickly. To the circumstance of white lead being a basic compound containing two molecules of normal carbonate of lead and one of hydroxide is attributed the power it possesses of combining with oil to form a paint capable of producing a smooth working quality in the brush which all painters like. It is, however, one of the advantages claimed for zinc white that the paint made from it is not so readily discoloured by sulphuretted hydrogen gas. Instead of becoming changed, like lead paint, by this gas into a black sulphide, it becomes the white sulphide of zinc which, as already stated, is one of the constituents of lithopone. Judging from the Report of the Netherlands Government and our own experience at home, it is not the sulphuretted hydrogen in the air of our large towns which is the discolouring agent, so much as the sulphurous and sulphuric acids which are being given off in increasing quantities into the atmosphere owing to the larger consumption of coal-gas for illuminating and cooking purposes. Coal-gas attacks zinc white more readily than it does white lead. It is said—and this is a point to which we shall return—that greater skill and care are required with zinc than lead paints, and that they must be applied in thin layers. Zinc white requires from 16 to 20 per cent. of oil to grind it into a stiff paste with a minimum of turpentine.

Oxide of zinc is not a dryer like white lead. Dr. A. P. Laurie,* of the Heriot-Watt College, Edinburgh, raises on this point an important question as to what is meant by "drying." As applied to water the term means loss by evaporation, but as regards spirit varnish it means evaporation of spirit and an undissolved resin left behind. In the drying of linseed-oil the oil absorbs oxygen, and the fatty acid of the oil becomes converted into oxy-linoleic acid, which is the most stable form linseed-oil can assume. Raw linseed-oil when exposed to the air takes days to dry, but the drying process can be hastened by treating the oil with white lead. The white lead is of itself a drier, so that of two surfaces painted respectively with white lead and zinc, each containing its proper proportion of oil and exposed to the air, the surface, painted with white lead dries the more quickly. Laurie maintains, notwithstanding the fact of the painted surface being thinner, that weight for weight zinc white has as good covering power as the carbonate of lead. Cruickshank Smith gives as the spreading capacity

* "The Paint Question," J. Cruickshank Smith, 1909.

in square yards per hundredweight the following: Oxide of zinc, 870; red lead, 424; white lead, 614 to 806; the prices per hundredweight in shillings being 46, 28, and 28 to 32, respectively; and the estimated numbers of tons required for painting the surfaces in twenty years being 4, 4, and 5 to 6.

When the proposed interdiction of lead paints was being discussed in the French Legislative Assembly, opinions of experts upon the relative merits of zinc and lead were quoted. It was stated that the naval engineers of Rouen, after three years' experience of both pigments, preferred zinc to lead, since the white colour of the paint did not blacken under the influence of sulphur. Equally favourable to zinc were the opinions of the naval engineers of Bordeaux. At the request of the French Government, experiments dealing with the covering and enduring power of the two paints were carried out at the Annexe of the Pasteur Institute, Paris. A Commission nominated by the Society of Public Medicine and of Hygiene undertook a series of experiments with the object of comparing surfaces painted with zinc and lead bases. The Commission was composed of Dr. L. Martin, M. Livache (a chemist), and M. Vaillant (an architect), along with Messrs. Mauger, Wernet, and Rigolet, representing the building trades of Paris.

In 1902, under the supervision of this Commission, a working painter applied paints containing zinc and lead bases to similar surfaces, and a few months afterwards the following report was published: (1) The colour and the polish of zinc white are equal to those of white lead; (2) the covering power and drying are practically the same. In order to test the enduring properties of the paints, it was necessary to allow atmospheric agents to exercise their destructive influence over a longer period. It was therefore arranged to examine the painted surfaces a year afterwards.

In October, 1903, the Commission reported that there was no appreciable difference between the paintings so far as concerned their reaction to atmospheric influences, and that both for internal and external painting the results were absolutely comparable.

Since 1903 three additional examinations of the painted surfaces have been made—viz., on September 30, 1904, October 11, 1905, and October 31, 1906, all the reports of which confirm the previous statement.

Zinc sulphide and lithopone are also spoken of as substitutes for lead carbonate. Lithopone is obtained by the double decomposition of barium sulphide and zinc sulphate. The precipitate consists of barium sulphate and zinc sulphide. The precipitate, which is beautifully white, is washed, dried, ground, and mixed with oil to form a paste which has all the appearance of white lead paint. Lithopone was placed upon the market as a substitute for white lead. Petit says that it has less covering power than lead, owing to the large quantity of barium sulphate it contains—viz., 67 per cent.

Applied to iron surfaces, the zinc sulphide of the lithopone is said to part with its sulphur to the metal and to form iron sulphide, also that, while the zinc sulphide mixes readily enough with oil, yet, owing to a process of vulcanization, it is liable to undergo decomposition.

Dr. Ignace Kaup informs us that the master-decorators of Vienna have recently been substituting zinc white, also lithopone, for lead carbonate in private dwellings, but that for public buildings white lead and varnish are still used. Only recently several of the workmen when painting a large Government building in Vienna became ill. The illness, rightly or wrongly, was attributed to plumbism. Master-painters both at home and abroad are divided in their opinions as to the value of lithopone. Some hold that it does not retain its colour well, and that its covering power is not so good as that of white lead. It is said to be all right on plaster, but not so satisfactory on wood, especially if the wood is new. Lithopone possesses the advantage of being about 4s. per hundredweight cheaper than white lead. In some of the Swiss railway carriage works only zinc white and lithopone are used.

It is hardly necessary to discuss at length the question of the use of sulphate of lead as a substitute for lead carbonate. From a paint point of view both have about equal values. Although it has hitherto been generally believed that lead sulphate is less soluble in the juices of the alimentary canal than the carbonate, and therefore less likely to be absorbed, the data obtained from recent experiments are conflicting. Lead sulphate can therefore not be regarded as a substitute for the carbonate, since it would only be replacing one lead paint by another.

As I wished to know the opinion of British master painters and decorators upon the relative merits of zinc white and lead carbonate, I applied to the Employers' Association, and in April, 1913, received the following information: Of 45 master-painters who replied, 43 expressed themselves in favour of white lead for the exterior of buildings; for inside work 17 preferred zinc white to lead. For internal decoration there is no reason why zinc white should not be more frequently used than it is, but for the external painting of houses the majority of master-painters seem to be in favour of lead paint.

There is a hygienic aspect of house-painting to which attention ought to be drawn. I refer to the antiseptic properties of paints. Two years ago Professor H. J. Hutchens and I carried out a series of experiments with various paints to test their germicidal powers. The micro-organism used was the *Bacillus coli*. The experiments extended over a period of three and a half months. We found that vapour from drying paint at 37° C. possessed definite bactericidal properties; it retarded and prevented the growth of micro-organisms. Paints which had been dried for forty-eight hours exercised a similar influence, but after five days they no longer possessed such power. Similar results were obtained by H. A. Gardner. Like myself, he attaches considerable importance to the circumstance, for by painting chambers with an oil pigment we have an efficient means of destroying bacteria in rooms which have been occupied by persons who were the subjects of contagious disease. During painting the rooms should be well ventilated, but when finished they should be closed for a day or two, to allow of the vapours exercising their antiseptic influence upon the walls and contents.

Lead Poisoning among Painters

In Great Britain it is difficult to estimate the amount of lead poisoning in painters, owing to notification of plumbism being voluntary, also to the fact that house and ship painting do not come within the Factory Act. The figures received under voluntary notification show lead poisoning to be even more prevalent among painters than was expected, also that it is increasing. These remarks apply equally to painters in Germany, France, Austria, and the United States. Painters have a higher mortality than the general population. In Berlin in 1903 the general death rate per 1,000 inhabitants was 11·61, but for painters it was 14. Fleck * gives as the mortality rates of German painters 1·3 per cent. from lead poisoning; nervous diseases, 7·8 per cent.; heart, kidney and liver disease, 20·8 per cent. Figures taken from the Prudential Insurance Company of America show the deaths from the same causes to be 1·5, 10·7, and 35·9 per cent. respectively. Among German painters diseases of the respiratory organs caused 41·6 per cent. of deaths, and in the United States 26·3 per cent.

Taking all the paint industries—and in these are

* Weyl, "Handbuch der Arbeiter Krankheiten," p. 513, Jena, 1908.

included house, coach, ship, and automobile painting—the cases of plumbism reported to the Home Office * were: 154 cases with 4 deaths in 1908; 197 cases with 9 deaths in 1909; 159 cases with 12 deaths in 1910; 316 cases with 12 deaths in 1911; and 204 cases with 12 deaths in 1912. Coach-painting furnishes the largest number of cases of plumbism.

Between 1900 and 1909 there were reported to the Home Office 1,973 cases of lead poisoning with 380 deaths of house-painters. In the tables furnished by Dr. Legge one important fact stands out, and that is the large amount of paralysis among the men. Tancquerel des Planches found the percentage of paralysis in lead-poisoned French house-painters to be 8, and Teleky 14·5 in Austrian painters. During the period above mentioned the British tables show the percentage to be 22·7. Teleky distinguishes between painters employed on the outside of buildings and those employed in decorating rooms. Of 100 painters of the interior of houses, 31·2 of the men were off ill annually—0·7 from lead poisoning, and 3·4 from tuberculosis; while of 100 painters employed on outside work, 47·4 of the men were off ill annually—7·7 from plumbism, and 4·3 from tuberculosis. If

* Annual Report of the Chief Inspector of Factories, 1912.

the figures for Berlin are taken, there were between 1900 and 1909 on an average 376 men off ill per year; if 100 members only are considered, 46·9 men were off ill per year—8·11 of these from plumbism. The smaller number of cases of lead poisoning among the Vienna painters who were employed on inside work is to be explained by the circumstance that other metals than lead were being used in the paint; for if similar lead paint had been used internally as externally, the cases would have been more numerous. That is the conclusion we come to from the following: In Vienna, for internal painting, there were used annually 1,600 hundredweights of white lead. This amount of material caused 163 cases of lead poisoning. For outside painting 4,750 hundredweights were used, and this gave rise to 50 cases of lead poisoning.

In the United States it was found that 1 in every 6 painters, and in Austria 1 in 4, gave a history of having had plumbism in one or other of its minor forms; but, bearing in mind what has been stated in the preceding pages regarding the increase in the number of drying agents now used, it is more than probable that part of the illness the men suffered from was of the nature of an intoxication from turpentine and its congeners, or from carbon monoxide, as suggested by Gardner, rather than lead; for if there is one circumstance peculiar to the plumbism of painters, it is that, owing to the gradual absorption of lead, the malady develops slowly and is usually associated with some such lesion of the nervous system as paralysis or with implication of the kidneys. It is seldom that a painter dies from uncomplicated and acute lead poisoning.

Among the common complaints of painters may be mentioned constipation and headache. Some writers state that 50 per cent. of the men suffer thus. This is, I think, pitching the number too high. House, ship, and coach painters are credited with a large number of ailments, of which the following may be mentioned:

Colic, ringing noises in the ears, vertigo, rheumatic pains, nocturnal micturition, disagreeable taste in the mouth, disordered sensations, imperfect vision, epistaxis, loss of appetite, sleeplessness, diarrhœa, tremors, gout, and depression of spirits.

Manufacture of China and Earthenware

This important industry, although met with in various parts of England and Scotland, is mostly located in the north of Staffordshire, where, when first commenced, it was close to the clay and coal fields, and where at the present time it gives employment directly and indirectly to several thousands of people. The district is known as the Potteries. The manufacture of pottery is a frequent cause of plumbism, owing mainly to the presence of lead in the glaze—that is, the liquid into which the ware is dipped. When, in 1898, Sir Edward Thorpe and I were sent by the Home Secretary to the Potteries to inquire into the prevalence of lead poisoning among the workpeople, we found several of the small master-potters using glazes which contained 20 to 30 per cent. or more of raw lead. By reducing the amount of lead in this glaze, and the Home Office introducing other reforms, lead poisoning in the manufacture of pottery has during the last decade considerably declined. Exposure of workpeople to small quantities of lead dust over an extended period is sufficient to cause symptoms of plumbism. Although in pottery workers the percentage of paralysis is fairly high, it is not always proportional to the length of employment in the factory. In only a small percentage of persons working in pottery is lead poisoning fatal—only 0·1 in persons employed in lead processes, or, in other words, 1 in 1,000. The following are the numbers of cases of lead poisoning and the deaths notified to the Home Office as occurring in the china and earthware trades of the United Kingdom :

	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.
Cases	200	106	87	97	106	84	107	103	117	58	77	92	80
Deaths	8	5	4	3	4	3	4	9	12	5	11	6	14

It is noteworthy that, while there is a marked declension in the number of cases of lead poisoning notified as occurring in lead workers, the sliding scale is not uniform, but interrupted. The deaths from plumbism have not fallen, but risen, as the cases notified have become fewer.

To explain the rising mortality rate, it is possible, as some writers maintain, that medical men are straining to bring within the category of death from lead poisoning diseases due to other causes. The modern medical practitioner is more familiar with chronic plumbism that was his predecessor, so there may be a disposition on the part of some of them to attribute to lead deaths due to other causes. On the other hand, opposed to this is the important fact that deaths are still taking place from lead without the true cause being recognized.

Fourteen years ago Sir Edward Thorpe and I, in our report to the Home Secretary, recommended that there should be a considerable reduction in the amount of lead in the glaze; that the lead should be "fritted," so as to render it more insoluble; that wherever possible leadless should be substituted for leaded glazes; and that female labour should be abolished in certain departments wherein lead or its compounds are used. "Fritted" lead, which is made by firing white lead with silica or boric acid, is a brittle, glass-like material. Thus "fritted," or "vitrified," the lead becomes less soluble in acids, and therefore less dangerous to the workers, than the carbonate of lead. Where lead carbonate—*i.e.*, raw lead—is used in a factory, the men who mix the glaze, the dippers who plunge the ware into it, and the dippers' assistants who remove and carry away the ware, incur the risk of becoming poisoned by lead. In dipping the ware into the glaze the men work with their sleeves rolled up; they immerse the pieces quickly, swirl them round when lifting them out of the tub, and as a consequence there is a good deal of splashing. The material splashed upon the floor and bench becomes dried, and is subsequently raised into the air of the dipping-room in the form of very fine dust. It is therefore desirable that the lead in the glaze should be changed into such a chemical and physical state as to be rendered comparatively insoluble in the stomach if swallowed, or in the respiratory passages if inhaled. When fritted, lead fulfils this requirement, for when melted at a high temperature with silica the metal becomes imprisoned in such a manner as to be attacked less readily by the acid of the gastric juice, and therefore less likely to be absorbed into the system. If the fritting has been well done, only a minute quantity of the lead remains in a soluble form. Glazes made with fritted lead are spoken of as glazes of a low solubility. As a result of experiments carried out by Thorpe, it was evident that there ought to be in pottery manufacture a standard of insolubility for fritted lead glazes. The standard of insolubility recommended was that glazes should not yield more than 2 per cent. of lead, calculated as lead monoxide, when acted upon by a weak solution of hydrochloric acid under certain specified conditions. This 2 per cent. standard of insolubility was regarded by the manufacturers as too high. A compromise between the manufacturers and the Home Office was effected, and a standard of 5 per cent. insolubility agreed to.

A test which gives approximately the amount of lead in pottery glaze has been suggested by Mr. H. R. Rogers,* H.M. Inspector of Factories. This consists in treating glaze with hydrofluoric acid for forty seconds, and of absorbing the liquid with filter-paper. The lead is precipitated on the paper as sulphate; thereafter any of the sulphate

* "Report of a Series of Experiments for Determining the Amount of Lead in the Glaze of Finished Ware."

which is soluble in water is washed away. The lead on the paper is precipitated as sulphide; the tints produced vary according to the proportion of lead in the glaze. In Austria a rough-and-ready test is made upon pottery by the factory inspectors. In some parts of the country cooking utensils are dipped in glazes rich in raw lead. These with other kinds of domestic ware are sold in the market-place. The factory inspector takes certain dishes, and pours upon them a small quantity of diluted acetic acid. After a few minutes the fluid is poured off and tested for lead with a sulphide. If the brown tint obtained is of such a depth as to indicate the presence of lead in considerable quantity the ware is not allowed to be sold. Since the publication of the Thorpe-Oliver report, subsequent Home Office Committees have reported upon the prevalence of lead poisoning among potters, and introduced improvements, with the result that, although the conditions are not as satisfactory as they ought to be, they yet show considerable improvement to those which existed a few years ago. In the following table is given the number of cases of lead poisoning among dippers and ware cleaners in the United Kingdom, taken from the Annual Report of the Chief Inspector of Factories for 1912:

CASES OF LEAD POISONING AMONG POTTERY WORKERS IN GREAT BRITAIN.

Processes.		Persons employed in 1907.	Cases reported in 1912.	Cases reported.				Attack Rate per 1,000 employed.				
					Average.					Average.		
				1911.	1907-1910.	1903-1906.	1899-1902.	1912.	1911.	1907-1910.	1903-1906.	1899-1902.
In dipping-house:												
Dippers	M.	786	18	16	17	18	26	23	20	22	23	34
	F.	150	—	6	6	4	7	—	40	40	30	68
Dippers' Assistants	M.	463	3	2	3	3	7	7	4	7	7	15
	F.	397	6	14	13	18	17	15	35	33	46	45
Ware Cleaners	M.	115	1	—	1	2	3	9	—	9	20	30
	F.	461	15	15	15	18	30	33	33	33	41	65
Total	M.	1364	22	18	21	23	36	16	13	15	17	27
	F.	1008	21	35	34	40	54	21	35	34	42	58

Dipping is anything but cleanly work. The hands and forearms of the dipper are repeatedly being dipped into glaze containing lead. One in forty-three of these men suffer from plumbism, probably more from inhaling the dried lead glaze than from absorption through the skin.

Dippers' assistants are usually young persons. At present young persons of fifteen years of age may be employed; but where lead glazes are used no great hardship would be inflicted if the age was raised to seventeen. Female dippers' assistants are more liable to plumbism than male assistants, as seen from the table.

In some factories, particularly in France, gloves are worn by the men and women who dip the ware, or the pieces are lifted by means of tongs, and thereby immersed in the glaze. The less there is of splashing and the cleaner a dipping-house is kept, so will dippers and their assistants be freer from plumbism, for it is the dried glaze on the floor, the tubs, benches, boots and clothes of the workpeople, which constitutes the danger. Much good would be effected, too, by washing or swilling of the floor every day or two.

In my earlier visits to the Potteries, I was struck by the large amount of sickness among the majolica paintresses. Many of them looked ill. They were pale and the subjects of saturnine cachexia. At the periods I refer to, glazes containing large quantities of raw lead were being used. Majolica painting is not skilled work. The glaze is roughly applied by hand; many of the women are careless, and there is much splashing of the glaze. Among majolica painters the cases of lead poisoning reported for 1912 were 1 male and 3 females; in 1911 no males, 4 females. In enamel colouring and glaze blowing there were 2 cases of lead poisoning in males in 1912, and 11 in females; in 1911 no males, 2 females. Persons employed in making litho transfers for the transfer of colours to china and earthenware are exposed to the risks of plumbism.

Manufacture of Pottery as a Home Industry

In Great Britain we see nothing of the injury to health brought about by the manufacture of pottery in the home such as is seen, for example, in Hungary. In order to study the question, I have visited Hungary on four occasions. The pursuits of the people are mostly agricultural. Here and there, scattered throughout the country, are villages occupied by working potters who carry on their trade in the home. The rooms in which the family live and sleep are those in which the clay is turned and the ware dipped; and as there are large quantities of raw lead in the glaze, not only do many of the potters themselves suffer from lead poisoning, but also the women and children. On the occasion of my visit to Hodmezovasarhely, eighty master-potters met me to discuss questions as to whether something could not be done to diminish or abolish the ravages of plumbism. Nearly one-half of the men who met me were paralyzed in the legs or face. Most of them were under forty years of age. Some of them had been paralyzed five or six years. Several of the wives and children were also paralyzed. A few of the children were blind as a consequence of saturnine encephalopathy; others were imbecile and had never walked, although upwards of four years of age. In another village—Csákvar—I found the potters were using a glaze containing 60 per cent. of lead carbonate. The dipping of the ware was carried on in the same room as that in which the family lived and slept. On analyzing the dust taken from the shelves of the rooms, Dr. Adalbert Chyzer, who accompanied me, found that it contained 0·63 to 1·08 per cent. of lead. He also found in the blouse worn by a little boy, the son of a potter, 0·243 grain of lead, and in his cap 0·0144 grain of lead. In the clothes which enwrapped an infant lying in its cradle lead was also found. On the gums of some of the children I observed a well-marked blue line. Many of the boys and girls were anæmic.

The children of these Hungarian potters are born into and reared in an atmosphere impregnated with lead, owing to the glaze on the floor, which has been splashed from the dipping-tub, becoming dried and raised into the air as fine dust. So high is the infant mortality rate that in some of the pottery villages there is hardly a child to be seen. In the homes of the potters domestic animals can hardly live. This is especially true of cats. A few years ago, at the request of the Home Secretary of Hungary, I reported upon the lead poisoning of the potters, and I recommended to the Government, among other things, the advisability of having the dipping and drying of the ware carried on away from the homes of the potters, in a communal workshop, also the necessity of using smaller percentages of lead, and where possible the use of fritted instead of raw lead. In August, 1913, I was again in Hungary, and at the request of the Minister of Commerce I visited Csákvar with M. Szanto, of the Museum of Social Service, Budapest, in order to see for myself the manufacture of pottery under the conditions I had recommended. In passing through Csákvar we were joined by Dr. Grásser, with whom five years previously I had discussed the problem of how to prevent lead poisoning of the potter, his wife and children. At the communal workshop, where fritted lead glaze is made and sold and dipping of the ware carried on, we met Count Esterhazy, who with his father has played an important part in trying to improve the health conditions under which pottery as a home industry is carried on in Hungary. On visiting the homes of the potters who bought and used the fritted lead, not only were they cleaner and brighter than those who still adhered to the old custom of mixing the glaze in the living-room, and of dipping the ware therein, but the health of the potters had considerably improved. So much was this the case that Dr. Grásser, in his desire to find for me a lead-poisoned potter's child, had sought through all the village without finding one. The following table, kindly supplied to me by Dr. Grásser, shows how severely scourged with lead poisoning Csákvar has been since 1900, and the satisfactory declension since the manufacture of pottery has become less of a home industry. From 1900 to 1912 Dr. Grásser treated 434 cases of lead poisoning—322 men and 102 women. Children are not included.

Year.	Men.	Women.	Total.
1900	40	5	45
1901	50	12	62
1902	35	10	45
1903	25	14	39
1904	30	11	41
1905	24	10	34
1906	25	12	37
1907	23	4	27
1908	32	15	47
1909	12	4	16
1910	11	2	13
1911	4	—	4
1912	11	3	14

It is not contended that the fewer cases of lead poisoning during the last few years are entirely the result of the recommendations made by the Hungarian medical men and myself in 1908, for the number of families engaged in the manufacture of pottery has declined, the men have become more temperate as regards the use of alcohol, and many of them have taken up agricultural work during certain periods of the year;

but notwithstanding these, the campaign against plumbism in the Hungarian villages has been followed by encouraging results owing to the improved conditions under which the work is now carried on. There have been fewer cases of plumbism among the married women, whilst amongst the children the malady has, practically speaking, disappeared.

The large number of trades in which lead is used, and with injury to the persons occupied in them, makes it impossible for me to deal with each trade separately, and to point out the dangers incidental to it. One or two trades, however, may be mentioned. File-cutting by hand is one. Among file-cutters the sickness and mortality rates from plumbism and tuberculosis are high. The transverse and crossed marks which are seen on a file are made by hand by means of a chisel and hammer. The tool about to be dealt with is strapped on to a bed or cushion of metallic lead. After having been cut on one side, the file-cutter reverses the file, at the same time rubbing it with charcoal or chalk. Chisel and hammer are again used, and in doing so much fine dust is raised. In dust removed from the wooden " stock " on which the man or woman sits astride when cutting the file, there was found 14·82 and 22·28 grains of lead per 100. Most of this is lead in metallic form, but, as oxidation is always going on, much of the lead is being constantly transformed into a readily soluble oxide. Sheffield is the cradle of the file-cutting industry, and there it is carried on also in the homes. The workshops and dwelling-houses in which the trade is carried on are dirty. File-cutters are not a cleanly body of men. To want of cleanliness, to inhalation of dust, to the habit of not washing before eating, also to working in close and ill-ventilated rooms, must be attributed the high mortality of file-cutters hitherto. File-cutters are no longer ignorant of the dangers of their occupation, so that while in 1899 and 1900 there were 41 and 40 cases of lead poisoning notified, with 1 and 3 deaths respectively, in 1909 there were only 8 cases reported and no deaths.

During the ten years 1900 to 1909 inclusive there were reported in the United Kingdom 241 cases of plumbism in file-cutters. Of these 19 terminated fatally. As the men who temper or harden the files by plunging them into a bath of molten lead also incur the risk of becoming lead-poisoned, hoods ought to be erected above the baths, so that the fumes are carried away from the workers. Instead of plunging the cut files into a bath of molten lead in order to harden them, the same result can be obtained by inserting them between hot iron bars, and in this way one danger is at least got rid of. Attempts have been made to replace by various substitutes the lead cushion on which the file is cut, but so far no pad has been found which possesses the elasticity and other required properties offered by lead. File-cutters are extremely conservative in their work, and are averse to innovations. So, too, are the men who use the files. Machine-made files are, however, coming more into general use, and they are gradually replacing those made by hand. In one way and another a change is creeping over the file-cutting industry of this country.

Electrical Accumulator Works

The increasing uses to which electricity is being applied, and the growing demand for storage batteries, have given an impetus to electrical accumulator works both at home and abroad. A paste made of red lead and sulphuric acid is rubbed into the perforated metal plates which are used in the construction of electrical batteries. In rubbing in the paste the men wear indiarubber gloves, but as a result of friction, also of wear and tear, the gloves become thin and torn, so that through the slits in the gloves some of the paste gets rubbed into the skin. The men who mix the red lead and acid are exposed to dust. During eleven years ending 1909, there were 317, not including 6 fatal, cases of lead poisoning notified as occurring in men employed in electrical accumulator works. Most of the plumbism occurs in the men who are employed in the mixing department, but their fellow-workmen who cast the plates, and those who solder them by means of a blowpipe, also suffer from saturnism by inhaling the fumes.

Printing and Type Founding

Another occupation in which the dangers of lead poisoning are frequently observed is that of printing, also type founding. In addition to plumbism, printers are peculiarly liable to tuberculosis, owing to the work being carried on in close, warm, and ill-ventilated rooms, whereby the possibility of infection is favoured. Some writers maintain that lead poisoning of itself predisposes to tuberculosis. The only way in which it can do so is by reducing the general vital resistance of the individual. When tuberculosis develops in a lead-poisoned person the phthisis usually runs a rapid course. Between 1900 and 1909 there were notified 200 cases of plumbism in printers, and of these 17 were fatal. Considering the large number of printers in this country, it cannot be said that lead poisoning is extremely prevalent among them, and yet when the malady develops the symptoms are unusually severe and persistent. In the dust given off by British type

14 per cent. of lead was found, but this is only one-third of what has been found in Continental printing-shops. Type-founders and linotypists suffer from plumbism through inhalation of the fumes of the molten metal.

If we take the statistics of the London Society of Compositors, it will be observed that there are fewer cases of plumbism among the members than of tuberculosis. Professor Hahn* of Munich has shown, taking the figures for Vienna and Berlin from 1901 to 1907, that the number of cases of plumbism and the mortality from tuberculosis run concurrently. In Vienna the sickness from plumbism per 100 members of one of the sick-clubs during eight years declined 48 per cent., and during the same period the deaths from tuberculosis declined 57 per cent. In Berlin during the years 1901 to 1907 lead poisoning declined 46 per cent., and the deaths from tuberculosis 40 per cent. Comparing the polygraphic trades one with another, it was noticed that, while the highest figures for plumbism were given by printers and type-founders, the highest death-rate from tuberculosis also occurred in printers and type founders. Hahn is of the opinion that the predisposition to pulmonary tuberculosis on the part of printers is the result of chronic lead poisoning; but if this alone were the cause, why should

* "Die Giesundheit."

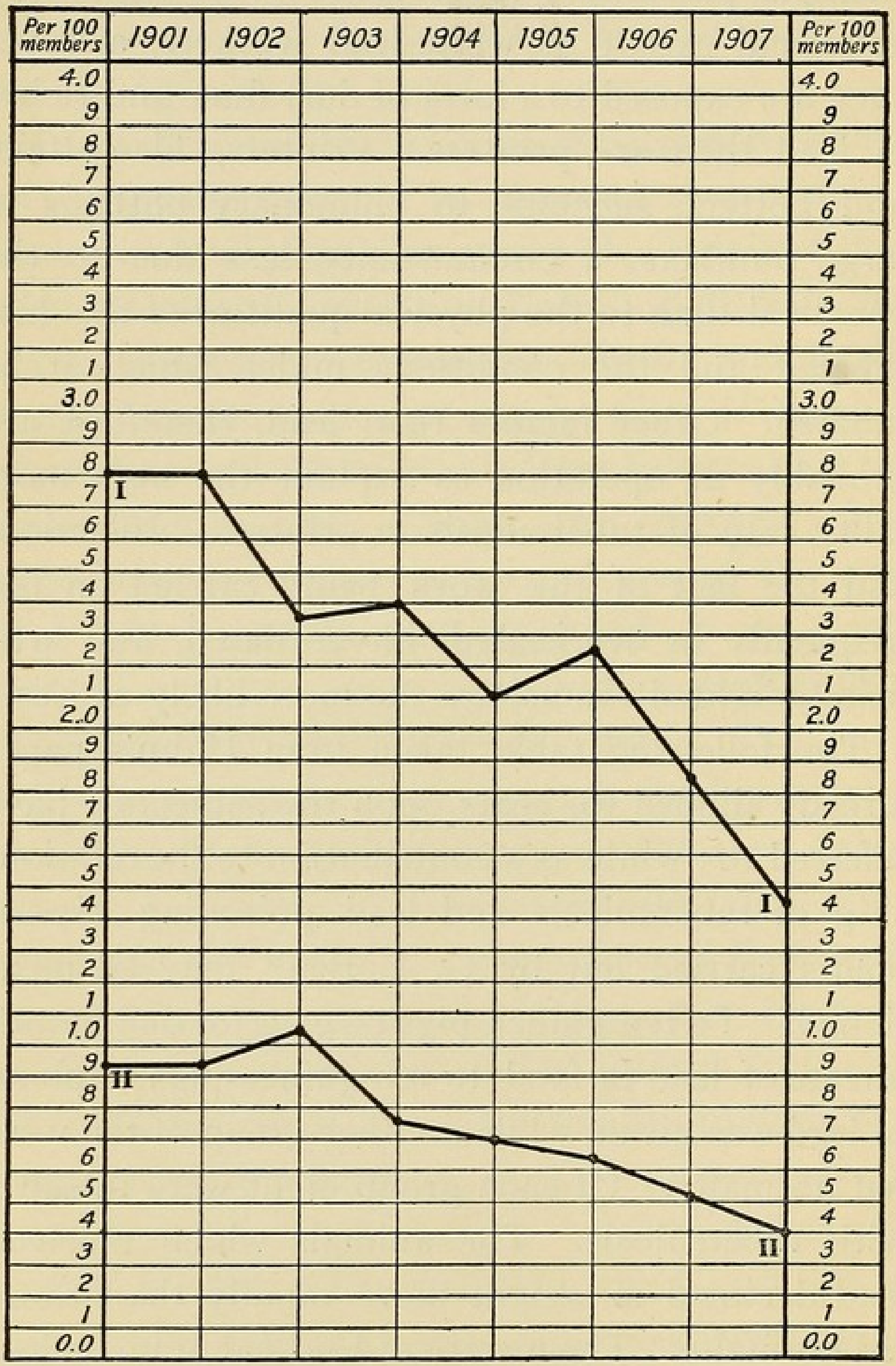
the relationship be so noticeable in printers, to the exclusion of other trades? We do not find, for example, pulmonary tuberculosis prevalent to any abnormal extent in white-lead workers, and yet they are exposed to a form of dust finer and richer in lead than are printers. Printers, file-cutters, and potters, succumb to pulmonary phthisis in large numbers, a circumstance less due to the chemical than to the physical qualities of the dust inhaled and the conditions under which it is inhaled. Other factors than lead, therefore, are probably in operation to explain the high mortality rate of tuberculosis in printers. Infection, and the fact of the work being carried on too frequently in overheated, ill-ventilated, and artificially-lighted rooms, are the more likely causes.

The following table, taken from Hahn's paper already alluded to, bears upon the subjects I have referred to; while as a contribution to the relationship of tuberculosis and lead poisoning experiments carried out by G. Loriga* may be mentioned. To ten guinea-pigs he gave for one month nitrate of lead in food, to ten guinea-pigs sulphate of lead was given, while another group of ten were fed normally. Of each group eight were infected with tuberculosis. The animals which received lead declined in weight more rapidly than those fed normally. The nitrate-of-lead-fed animals lost

* *Il Ramazzini*, 1912, Hft. I. and II.

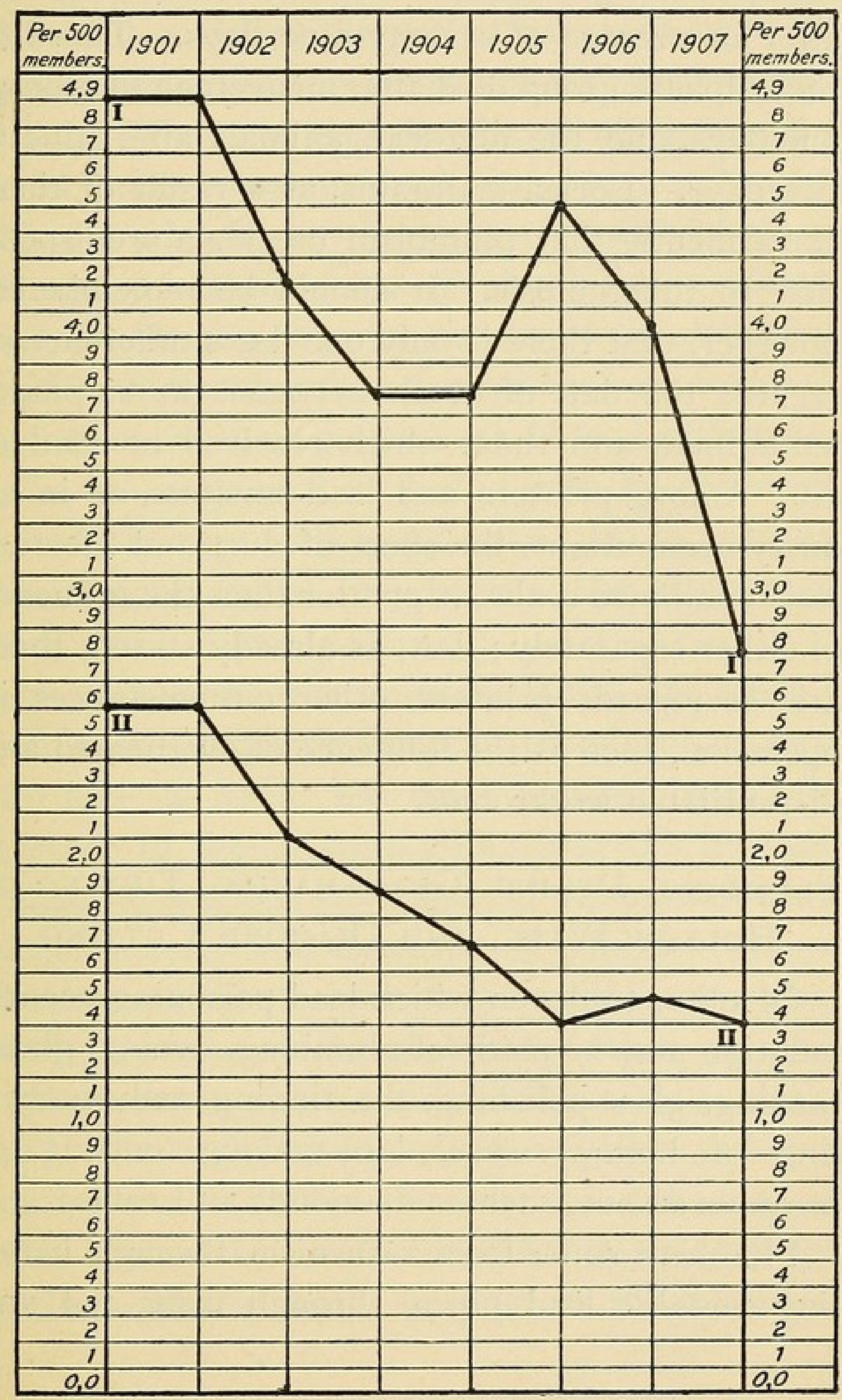
Sickness Rates from Lead Poisoning and Death Rates from Tuberculosis, per 100 Members, of Male and Female Members of the Vienna Book-Printers' Sick-Fund.

[I = Cases of lead poisoning. II = Deaths from tuberculosis.]



Sickness Rates from Lead Poisoning and Death Rates from Tuberculosis, per 500 Members, among Compositors and Printers of the Berlin Local Sick-Fund for the Book-Printing Trades.

[I = Cases of lead poisoning. II = Deaths from tuberculosis.]



weight more quickly than those which received sulphate. One of the nitrate-fed animals died of lead poisoning, and seven of the tuberculous group after an average of seventy-nine days. Those of the sulphate group died after an average of ninety-one days, and the non-lead animals after ninety-two days. Loriga maintains, as a result of these experiments, that plumbism creates a predisposition to tuberculosis. It should be remembered, however, that there is only one day's difference as regards the date of death between the sulphate-fed animals and those which received no lead at all. Among printers and lead-smelters, as in all dusty occupations, the effect of dust and tuberculosis combined is always greater than the influence of either separately ; but, as already stated, there are, as regards printers, other circumstances in operation, such as the influence of overheated and ill-ventilated workrooms.

Plumbing, Dyeing, Glass-making, Tinning of Hollow Ware, and Diamond Cutting

Of other trades in which lead poisoning occurs, mention may be made of plumbing, dyeing, glass-making, glass-polishing, the tinning and enamelling of hollow ware, lace-making, cutting of precious stones, such as diamonds and rubies.

Plumbers suffer from saturnism through handling metallic lead pipes, through using red and white lead for jointing purposes, also through handling putty. There is a belief that putty made with white lead keeps better than putty made without it, and that the putty made with red lead used by engineers sets more quickly and hardens better. Whatever may be the advantages conferred upon putty by lead, its presence therein adds considerably to the risks to health of those who use it. Many cases of plumbism have been traced to the use of putty powder in the polishing of glass. On analysis the powder has been found to contain as much as 70 per cent. of lead carbonate.

Persons employed in dyeing yarn by chromate of lead, dyeing of silk and thread, also in printing colours upon calico, may become the subjects of plumbism.

In glass-works where electric lamps are made I have observed severe forms of plumbism in men who mix the sand, salt cake, and red lead, preparatory to the mixture going into the furnace. Unless precautions are taken, the atmosphere soon becomes dusty and a source of danger to those who breathe it. I have seen healthy men who, within fourteen weeks of having taken up this employment in a glass-works, had become anæmic, had lost half a stone in weight, and were suffering from severe headache. On examining the men at work, I found their teeth covered with red particles of the oxide of lead, so that in these men a considerable quantity of the poison was becoming dissolved in the mouth and was being swallowed. Dr. Septimus Bodger, of Studley, Warwickshire, has drawn my attention to several cases of lead poisoning among women and girls employed in putting glass tops on the long hatpins worn by women. In many of the workers there was a well-marked blue line on the gums. Most of them were anæmic; pregnant females had miscarried in larger numbers than women employed in other trades in the district. The glass which was used came from Germany, and contained a large quantity of lead.

In what is called the tinning of hollow ware, the interior of the vessel is swilled with molten metal, a mixture of lead and tin. As tin is the more expensive, there may be as much as 70 per cent. of lead present in the molten metal used for tinning cheap goods. Not only do the men who swill the interior of hollow ware suffer, but the people who eat the food which has been cooked in the vessels are also liable to be poisoned by lead. Formerly the white enamel used for coating the interior of culinary ware contained large quantities of lead, but within recent years this metal has been replaced by a harmless substitute.

In the enamelling of iron baths, the men who grind the fritted lead (boro-silicate), and who put the enamel on the bath, frequently become lead-poisoned. The material is put on the bath, in the form of a fine powder through a sieve, when the iron bath is still extremely hot, the temperature being frequently as high as 1,500° F.

I have known an engraver become paralyzed as an incident in his occupation. Although etching is made on copperplate, there is frequently on the surface a small quantity of lead. The engraver referred to was in the habit, when at work, of putting the tip of the steel pencil into his mouth, with the result that he developed a well-marked blue line on his gums, had colic, and suffered from double wristdrop.

We do not find plumbism in lace-workers in Great Britain, but on the Continent it is not unknown, owing to lead being added to increase the weight of the lace. In Austria the use of lead for this purpose has recently been prohibited.

The cutting of diamonds is an old industry of Amsterdam. At the time of my visit to the diamond cutting shops of that city eight years ago, the industry gave employment to 8,000 men. The rooms in which the men work are overheated. In order to cut a diamond it has to be fixed in a mass of molten metal, the size of a walnut, composed of 60 parts of lead and 40 of tin. Thus fixed it is polished by hand or by a small wheel revolving very rapidly. Owing to the large amount of lead dust, usually lead oxide, floating in the atmosphere the men suffer from colic and wristdrop. At Reichenberg in Bohemia similar symptoms are met with in the men who cut precious stones.

How is Lead Poisoning caused?

Food and drinking water contaminated by lead are sources of plumbism; so, too, are certain occupations in which lead is carried into the atmosphere in the form of fume and dust. The malady occurs also as a consequence of the self-administration of diachylon, or lead plaster, for the purpose of procuring abortion. Canned foods, particularly preserved foods which have an acid reaction—*e.g.*, sliced pineapple — become possible causes of plumbism, through dissolving out the lead in the solder. One of my patients, an unmarried woman twenty-eight years of age, became seriously ill through eating tinned salmon. She became anæmic, developed wristdrop, her gums showed an intense blue line, and her urine contained lead. The paralysis slowly disappeared, but her health was never the same afterwards. Two years after her apparent recovery the urine still contained lead.

Drinking water gathered on peaty ground has frequently an acid reaction, and is capable of dissolving lead. Water possessing plumbo-solvent power has been the cause of widespread suffering, owing to lead poisoning assuming endemic proportions. This has been the case in several of the towns and villages of Yorkshire. The plumbo-solvency of drinking water varies with the season of the year. It is apt to be increased at the end of a long drought, owing to the rain washing out the humic or ulmic acid contained in the peat. Houston, of the Local Government Board, a few years ago drew attention to the acidity of peat, and the part it plays in the presence of bacteria. If to a sterile decoction of peat micro-organisms obtained from peat are added, the liquid becomes acid, and is found to possess strong plumbo-solvent powers. Two non-motile, non-liquefying bacteria have been isolated from peat by Houston. These organisms possess separately the properties of acidity and plumbo-solvency. In my own experiments, drinking waters richest in bacteria, not of peaty origin, possessed slightly greater solvent power upon lead than those poor in micro-organisms. Distilled water attacks lead with greater vehemence than might be expected. In fact, unless glass vessels are used in the process of distillation, it is difficult to get the ordinary distilled water of commerce completely free from lead. Ordinary drinking water acts upon lead owing largely to the oxygen dissolved in the water. The presence of calcium carbonate in the water gives a protective coating to the interior of lead pipes, provided the water remains free from acid. Such salts as nitrates and chlorides in water exercise a distinctly corroding influence upon lead. Carbonic acid has a similar influence. Silicates, on the other hand, possess protective properties. On the addition to drinking water of fragments of limestone, magnesium limestone, and chalk, waters which were previously strongly plumbo - solvent lose this property, and are rendered safe for domestic purposes. Usually only very small quantities of the protective agent are required—*e.g.*, 2 to 3 grains of lime, $1\frac{1}{2}$ grains of powdered chalk, or whiting, added to the gallon of water, being sufficient. One method which has been found most serviceable is filtering of the water through sand rich in silicates and strewn with fragments of limestone. In association with my colleague, Professor R. A. Bolam, I have carried out several experiments with drinking waters which, owing to their high plumbo-solvency, were causing widespread and serious harm, further extension of which was only prevented by prompt and appropriate chemical treatment of the water. I give in the following tables the amounts of lead dissolved daily by 50 c.c. of drinking water. The tables show what can be effected by treatment, also the necessity of constant watchfulness on the part of a water company when it is known that the water supplied possesses strong plumbo-solvent powers. Our plan is to immerse a piece of lead pipe in water, and to leave it, testing the fluid daily.

	June, 1901.			June, 1912.
	Unfiltered Water.	The Same Water treated.		Water from Same Source treated.
June 15 ...	0·7	0·15		
" 16 ...	1·05	0·3		
" 17 ...	1·25	0·35	June 17 ...	Pipes immersed
" 18 ...	1·4	0·4	" 18 ...	0·05
" 19 ...	1·8	0·4	" 19 ...	0·1
" 20 ...	1·8	0·45	" 20 ...	0·15
" 21 ...	1·9	0·45	" 21 ...	0·2
" 22 ...	2·0	0·45	" 22 ...	0·25
" 23 ...	2·1	0·45	" 23 ...	No determination
" 24 ...	2·2	0·5	" 24 ...	0·3
" 25 ...	2·3	0·5	" 25 ...	0·35
" 26 ...	2·4	0·5	" 26 ...	0·4
" 27 ...	2·4	0·5	" 27 ...	0·4
" 28 ...	2·5	0·5	" 28 ...	0·4
" 29 ...	2·6	0·5	" 29 ...	0·4
" 30 ...	2·6	0·5	" 30 ...	No determination

The above are amounts of lead in milligrammes per ½ litre of water.

Compare with these the amounts of lead dissolved by the waters supplied by another water company :

	M (not treated).	N (treated).
July 9 ...	Pipes immersed	—
„ 10 ...	3·2	0·5
„ 11 ...	5·3	0·55
„ 12 ...	6·1	0·8
„ 13 ...	—	0·95
„ 14 ...	—	1·0
„ 15 ...	—	1·1
„ 16 ...	—	1·1

The above are amounts of lead in milligrammes per ½ litre of water.

The effect of treatment is apparent in N. Whenever drinking water has once been found to exhibit strong plumbo-solvent powers, in the interests of the public it is absolutely necessary that the water should be submitted from time to time to plumbo-solvency tests, for the capacity of the water to take up lead varies with the seasons of the year, also with the weather; and, besides, the silica and limestone which form the protective material laid down in the filtering bed are being gradually washed away, or their influence is weakened, and ought therefore to be periodically renewed.

A feature of the widespread plumbism due to contaminated drinking water is that women and children are likely to suffer more than men, and that usually there is among the adult female population a larger number of miscarriages. Occasionally, in some of the towns supplied with a high plumbo-solvent water, the number of miscarriages, admittedly difficult to know accurately, is equal to, if not greater than, the live births in the affected area. Another point of interest, too, is that the destruction of immature infant life occurs without most of the women exhibiting symptoms of lead poisoning, or even showing a blue line on their gums.

FUME.

Fume escaping from the stacks of a lead-smelting works has, as we have seen, caused the death of animals grazing in adjoining fields. It is a cause of sickness, too, in the men who smelt the ore. Some men are more readily affected by fume than others. Symptoms of plumbism may develop slowly; in a similar manner, structural changes in the internal organs, such as the kidneys and arteries may develop slowly and insidiously, and cause cerebral hæmorrhage at an early age, so that it may be said through functional conditions to pathological changes we are led stage by stage to the final result, which cannot also but be regarded as a consequence of plumbism.

LEAD OR ITS COMPOUNDS IN THE FORM OF DUST.

Dust is the agent most provocative of plumbism. All lead compounds, whether oxide, chloride, carbonate, sulphate, nitrate, or chromate, are harmful. Lead gains access to the human body through the skin, by the respiratory organs, and by the mouth and alimentary canal. The substitution of wet for dry methods of manufacture of white lead has reduced the amount of illness among workers; so, too, has abolition of hand labour in the emptying of white beds and in the drying departments.

It is characteristic of lead poisoning that the absorption of minute quantities of lead continued daily for a few weeks or months is not only more likely to produce symptoms than one or two fairly large doses taken in rapid succession, but that the plumbism which develops will probably be more severe and persistent. Some persons are more prone to be affected by lead than others. There is an individual and a family predisposition to lead poisoning. Women and young persons, especially young females, are more readily affected by lead than men. My experience leads me to affirm not only the greater susceptibility of women to plumbism, but also to the worst types of it. It was on this account that I recommended to the Home Office the abolition of female labour in the dangerous processes of white lead manufacture, a step which has been followed by the happiest results. Other circumstances than sex predispose to plumbism—*e.g.*, poverty and its attendant ills. In my Goulstonian Lectures on Lead Poisoning, I drew attention to the fact that men and women who commenced their daily work in a lead factory without taking food became more readily affected than those who had breakfasted before going to the factory. A simple breakfast of bread and hot milk, tea, or coffee, provided by the employer, is one of the best preventives of plumbism amongst his factory hands. Alcoholism strongly predisposes to plumbism. Intemperate habits make men careless when at work and less cleanly in their habits. Excessive indulgence in alcohol destroys the taste for food. Men addicted to drink ought not to be allowed to work in a lead factory. In my experiments upon animals, I found that those which received alcohol in addition to lead were more readily poisoned than those which received lead alone. From appearances only it is not always easy to foretell who are the persons most likely to suffer from plumbism, but medical men whose function it is to examine applicants for work in a lead factory do well not to accept anæmic persons, those whose glandular system is wrong, whose digestion is not normal, persons suffering from constipation or who have kidney disease. One of the most searching examinations of applicants for work in a lead factory known to me is that carried out by Dr. Irvine, of Lemington-on-Tyne, at one of the largest lead-works in Newcastle-upon-Tyne. After inquiring into previous occupation, the heart and lungs are auscultated, the gums are carefully searched for possible traces of a blue line, the urine is tested for albumin, a sphygmogram is taken, and the blood-pressure recorded. It is needless to say that any man with albuminuria is rejected; so, too, all applicants who have a blood-pressure above 140 millimetres of mercury. To this rather searching examination and the weekly medical visit I attribute the remarkable freedom of the men in this particular factory from plumbism.

In lead-works, chewing and smoking of tobacco, especially cigarette-smoking, must be absolutely forbidden. Men who chew are apt when at work to draw out of their waistcoat pocket with their soiled fingers a piece of tobacco which may or may not be coated with lead dust. Some workmen are under the erroneous impression that chewing tobacco when at work prevents them becoming lead-poisoned, but on examining the mouth of these men the well-marked blue line on the gums, the discoloured teeth, and the unhealthy condition of the gums generally, do not lend support to this opinion. The abolition of the use of tobacco in a large white lead works in

Nantes was followed by results interesting enough to be recorded here. The average number of men employed in the works was 670. In 1902 the management forbade smoking for two years. In 1901 there had been twenty-six cases of lead poisoning in the factory, and in 1902 the number had risen to forty-two. The year after smoking was forbidden there were nine cases of plumbism, and in 1904 there were only four cases. It is not claimed by the manager that the improvement in the health of the men after 1902 was entirely the result of the prohibition of smoking, for some minor improvements had been introduced in the method of drying the white lead; but, taking this and all things into consideration, the manager was disposed to regard the better health of the men and their freedom from lead poisoning as the result of their abstaining from the use of tobacco when at work. While penning these notes I have seen a man twenty-six years of age, a mixer in a glass-works, with marked saturnine cachexia and well-marked blue line on his gums, who tells me that immediately the foreman leaves the room he and his comrades remove their respirators and smoke cigarettes. Wilfulness added to ignorance thus defeats the objects sought to be attained by regulations. The employment of casual labour should on these grounds be discouraged. Where men are regularly employed in a lead factory there is always less sickness among them ; and although some of the workmen are not as careful as they ought to be, they are yet more cleanly than casual labourers. In a white lead factory there must always be a certain amount of casual employment, for much of the work is unskilled, the men do not stay long at the work, and the supply of labour is not always equal to the demand.

Onset of Symptoms, and its Relation to Exposure to Lead.

Since idiosyncrasy plays an important part in the development of the malady, it is impossible to assign a date when symptoms of plumbism may show themselves in persons exposed to lead. One man may suffer from colic within a fortnight after taking up work in a white lead factory, while his comrade working alongside of him may not suffer for several months, or perhaps not at all. To idiosyncrasy must be added the influences of such personal qualities as cleanliness and temperance. I have seen a young woman die from saturnine encephalopathy ten weeks after taking up work in a white lead factory. One attack of plumbism predisposes to another ; but here again idiosyncrasy is an important factor, for some men may have one attack of colic and recover, or they suffer from loss of power of the hands and wrists, and this passes away, so that the men return to the lead factory and are able to follow their occupation for years without becoming ill. Such cases are not infrequent; they are interesting from a recovery point of view. In many lead workers there is observed a long period of presaturnism, extending, it may be, over a series of years, during which the men look pale and their gums show a well-marked blue line; but elimination of the metal apparently keeps pace with absorption, for lead is found in the urine and fæces, so that these men continue to follow their employment not complaining, and yet not feeling quite well. Sooner or later, but still without complaint of colic or of loss of muscular power—sometimes, too, without the presence of a blue line on the gums—they become the subjects of ill-health, the symptoms and physical signs suggest kidney disease and arteriosclerosis, both of which are recognized pathological effects of chronic plumbism.

If we take as the simplest type of plumbism the case of a person who has drunk water contaminated by lead, or a woman who has taken diachylon pills, the symptoms usually first complained of are severe abdominal pain referred to the neighbourhood of the umbilicus, to one or other side of it, pain of an aching nature, relieved by pressure in some instances, and in others aggravated by it. The colic is frequently accompanied by vomiting, and usually, but not always, by obstinate constipation. Abdominal pain may be the only symptom. A few days or weeks afterwards, and without necessarily being preceded by colic, the patient complains of weakness followed by loss of power in both hands and wrists. In lead workers symptoms of plumbism do not always develop quickly. The rate of poisoning is usually slow. Friends may have noticed and remarked upon the increasing pallor of the face, or it may be that the workman himself has complained of a metallic taste in the mouth in the morning, a disagreeable breath, disinclination for food, recurrent headache, colic, and ill-defined pains in the limbs. Headache may be the only symptom of plumbism, and it is characteristic of the headache that it is extremely severe.

Lead taken in drinking water is already in solution, but when swallowed in the form of diachylon or as dust in food, the compound has first to be dissolved in the gastric juice of the stomach before it can be absorbed by the mucous membrane and passed into the blood. In a series of digestion experiments carried out for me by Professor Bedson, of the Armstrong College, Newcastle-upon-Tyne, it was found that the gastric juice possessed strong solvent powers over white lead; the lead carbonate became converted into chloride, which is extremely soluble and dialyzable. Lead chloride passes fairly rapidly through animal membrane. Pepsin alone had no effect upon lead. The principal solvent in the stomach for lead is the dilute hydrochloric acid of the gastric juice. Lead chloride in intimate contact with proteid becomes lead albuminate, which is rather an insoluble and indiffusible substance. In the digestion experiments carried out by Bedson, it was found that if digestion of proteid food was going on at the same time the amount of lead dissolved was insignificant. This circumstance is of great importance from the point of view of the prevention of plumbism, and is one of the strongest reasons for employers giving a free meal to all workpeople before commencing work in a lead factory for the day. The more recent experiments of Carlson of Chicago support my contention. He found that where lead is added to gastric juice and milk, and the mixture is incubated at body temperature for ten hours, not enough lead goes into solution to give even a qualitative test of lead. Only in two instances where lead carbonate paint dust was used was there a qualitative test of lead obtained. If a fresh addition of hydrochloric acid was made, lead was dissolved in proportion to the hydrochloric acid added. The hydrochloric acid of the gastric juice is under ordinary circumstances fixed by the protein of the milk, and neutralization is effected by the alkaline salts present in the milk. It is generally believed that it is as lead chloride that lead when swallowed passes into the system from the stomach, and one reason why herbivorous animals, such as the rabbit, are not so rapidly brought under the influence of lead as omnivorous animals may be the relative deficiency of acid in their gastric juice.

Messrs. Moore, Oldershaw, and Williams,* are of the opinion that, taking into account the action and dosage of such a heavy metal as lead, the relative development of the intestinal mucous membrane must be considered when the question of absorption is being dealt with. In such omnivorous animals as cats and dogs, heavy metals are far more toxic proportionally than they are in herbivorous animals, owing to the shorter intestine of the omnivor. As lead under these circumstances tends to accumulate in the intestine, death occurs during the process of elimination. According to these writers, the intestinal mucous membrane is to be regarded as a path of elimination rather than of absorption. It is to be remembered that this remark applies to lead which was

* *British Medical Journal*, August 2, 1913.

introduced into the system by hypodermic administration, and not by the mouth. Lead administered hypodermically behaves like the *ions* of other heavy metals; it is eliminated by the intestinal mucous membrane, and in its excretion it causes irritation and congestion of the membrane; but it is otherwise when lead is swallowed, for digestion of the metal is completed within the alimentary canal itself, and absorption takes place from it. Where a soluble salt of lead unites with proteid it forms an insoluble albuminate, in which it has generally been held that the lead is simply retained mechanically in the albumin, but this is not the opinion come to by T. M. Clague and myself as the result of experiment. If such a substance is present in blood, a fluid rich in chloride, Moore holds that the lead may become reconverted into a soluble chloride in the presence of the contained sodium chloride. In this form it would readily circulate through the body and pass out by the kidneys. Legge and Goadby are of the opinion that, as lead particles are taken up by leucocytes, in whose interior the lead becomes converted into peptonate or albuminate, the lead is probably eliminated through the kidney in this colloidal form. Lead leaves the body in larger quantities by the fæces than by the urine. After the administration of lead salts by the mouth, Carlson found that 63 per cent. of the lead given as carbonate, and 95 per cent. as sulphate, escaped by the fæces.

When carrying out for me a series of digestive experiments, Professor Bedson found that bile dissolved three times more lead than gastric juice. Pancreatic juice rather hindered than encouraged the solution of lead. During pancreatic digestion alone no lead was dissolved in most of the experiments. Bedson's experiments were made with lead carbonate. It has been claimed by some writers that lead sulphate, owing to its lesser degree of solubility in the gastro-intestinal juices, is less harmful to persons working in it than is lead carbonate. Goadby is not of this opinion. He found that, while 0·048 and 0·042 per cent. of lead carbonate were dissolved, the quantities for lead sulphate were 0·080 and 0·046.

Dr. Alice Hamilton* gives a series of digestion experiments which were carried out in the Hull Physiological Laboratory of Chicago University by Messrs. A. J. Carlson and A. Woelfel. Goadby, as the result of his experiments, was led to regard lead sulphate as more soluble in gastric juice than lead carbonate; but Carlson, also making use of human gastric juice, found on an average 1·12

* "Hygiene of the Painters' Trade," *Bureau of Labour Statistics*, Bulletin 120. Washington, 1913.

grains of lead carbonate dissolved for 0·97 of basic lead sulphate. Carlson states that the greater solubility of lead sulphate in the gastric juice is a chemical impossibility. It is hardly necessary to remind readers that it is the hydrochloric acid of the gastric juice which is the principal solvent of lead salts. The Chicago Professor took basic lead sulphate paint dust, also basic lead carbonate paint dust, and he found that gastric juice dissolved 9·5 per cent. of the sulphate and 46·1 per cent. of carbonate. In a series of three experiments with human gastric juice, he found that 0·1235 gramme of lead sulphate was dissolved, equivalent to 24 per cent.; that in gastric juice with peptone 0·1330, or 26 per cent., was dissolved; whereas with lead carbonate the amounts were 0·2992 gramme, or 59·8 per cent., and in the peptone experiment 64 per cent. Instead of lead sulphate being more readily dissolved in gastric juice, Carlson found the carbonate to be twice more soluble than the sulphate.

In my own experiments I found lead carbonate to be more toxic than sulphate. Goadby found cats more readily poisoned by lead sulphate than by carbonate. Blum, on the other hand, found sulphate of lead to be less poisonous than the carbonate. Carlson administered lead sulphate paint dust and basic lead carbonate paint dust in meat to dogs, and he found that the dogs which received lead carbonate paint dust developed severe symptoms of lead poisoning within twenty-four to forty-eight hours after the first feeding; whereas dogs fed upon sulphate paint dust did not show symptoms of poisoning until after three to four feedings, or from seventy-two to ninety-six hours afterwards. Cats were exposed to a similar ordeal, with the result that lead carbonate and lead carbonate paint dust were found by Carlson to be more distinctly poisonous than basic lead sulphate and lead sulphate paint dust. I have given the details of these experiments owing to the controversial opinions expressed by various writers in regard to the comparative toxic values of lead carbonate and lead sulphate.

Experiments upon animals have helped to solve some of the problems connected with lead poisoning. Animals are not all alike in their behaviour towards lead, nor are human beings. Some are more susceptible than others. As regards animals, dogs and cats are readily brought under the influence of lead, but rats, especially wild-rats, also rabbits, are not so quickly influenced. Whether, as regards the rat, owing to the long association of his race with the metal, and the comparative ease with which the animal can gnaw through lead pipes without suffering, a kind of immunity to plumbism has been developed, I am not prepared to say. Rabbits, on account of being vegetable feeders, may on that account be more resistant than other animals. One of my laboratory rabbits took lead almost daily for three years. During that period it received by pipette 1,095 grains of nitrate of lead, equivalent to 684 grains of metallic lead. Usually one attack of plumbism predisposes to another. Long contact with the metal does not necessarily confer immunity. Lead is unlike many poisons. There can be no trifling with it. I have known men who had worked in a lead factory for thirty years without suffering from plumbism, yet become ill after such a long term of service.

Dr. Walter Straub of Freiburg has recently* suggested a method of inducing lead poisoning in animals which several years ago I had made use of. He injected under the skin of the back of a rabbit, on September 1, 1908, a quantity of freshly-precipitated lead carbonate. On November 7 the animal appeared to be quite well. Subsequently there slowly developed paralysis of the fore-limbs, and a few days afterwards the hind-limbs became the seat of spastic paraplegia. The muscles affected were mostly the abductors. The paralysis continued until the death of the animal.

* *Münchener Medizin. Wochenschrift*, January 6, 1914.

The animal died on January 30, 1909—*i.e.*, 124 days after receiving the lead—without having lost weight and without its appetite having been impaired. At the post-mortem examination of the body a considerable quantity of unabsorbed lead was found at the site of the injection. Cats similarly treated died within seven to twelve weeks after the injection, from bulbar paralysis, and with a distinct loss of body-weight. Erlenmeyer, who was associated with Straub, has given a good description of plumbism in cats. Aschoff found, on microscopical examination, structural changes in the spinal medulla, but not in all the animals. In one there was marked cellular infiltration of Goll's and Burdach's columns. Professor H. Schridde examined the blood of one of the cats before it died, but failed to find evidence of basophilia. The pathological findings are interesting, for bulbar symptoms are extremely rare in man. While in some of Straub's animals which showed signs of plumbism a large quantity of lead remained unabsorbed, others in whom all the lead had been absorbed did not show any symptoms of plumbism at all. The amount of lead absorbed during the eight to ten weeks the animals lived varied from 0·1 to 0·2 gramme, a small quantity admittedly, but it is common knowledge that it is the absorption of minute quantities of lead which gives rise to symptoms. Straub therefore regards 0·3 gramme—*i.e.*, 5 grains—of lead as capable of inducing plumbism.

Channels of Entrance of the Poison.

Considering the frequent opportunities offered to lead to enter the body by the skin, this surface cannot be regarded as a common mode of entrance, and yet serious symptoms, and even fatal results, have followed the application of lead externally. Wrist-drop is met with in men who cut leather on lead slabs. This may partly be the result of friction of the hand against the lead slab causing the dust to penetrate the moist skin, or it may be the result of the inhalation of fine particles of oxide of lead which come from the slab. Tancquerel des Planches tells us that in the Paris hospitals colic was never known to have followed the application of lead to the skin This is not my experience. I have treated an actress for colic, headache, and amaurosis with hæmorrhages into the retina, due to the use of cosmetics, and the reason why symptoms do not more frequently follow the use of cosmetics containing lead may be that the fat in the paste blocks the pores of the skin. Hair-dyes which contain lead have caused serious symptoms, while their use in one instance to my knowledge caused death. Dr. G. B. Morgan, of Sunderland, informs me that he was consulted by a maiden lady, seventy-two years of age, on account of a drooping of the left upper eyelid, double vision, muscular pains, severe headache, increasing feebleness, and constipation. In addition both arms were paretic, and there was divergent squint of the left eye. A week afterwards, as there was no improvement in the symptoms, Dr. Morgan ordered 7 grains of potassium iodide to be added to each dose of the medicine. On the following day the lady was found dead in bed. At the post-mortem examination nothing was found in the brain or in any part of the body to explain the symptoms and death. Two medical men who were present at the autopsy remarked upon the beautiful black hair of such an old woman. Two weeks afterwards a niece called upon Dr. Morgan, and gave him some powders which she had found in her aunt's chest of drawers. On analysis these were found to contain acetate of lead and sulphur. There was not the least doubt that the powders were used to dye the hair, and that the illness which developed was a consequence of their use. The iodide of potassium had redissolved lead which was lying in an insoluble form in the body and caused the rapidly fatal toxæmia.

Notwithstanding the above, the skin remains an uncommon mode of entrance of lead into the body. It is, however, a surface by which lead may be eliminated from the body. In some of my hospital patients Professor Bedson found lead in the perspiration.

Lead enters the body by the respiratory organs and passages. Men when working in the dusty atmosphere of a white lead factory cannot but inhale dust. Most of this is caught in the naso-pharynx and is swallowed, but some of the finer particles are carried onwards by the inspired air into the lungs. In whatever part of the respiratory passages lead-dust becomes deposited, it is brought under the influence of moisture and heat. The fluids secreted are alkaline, and as carbonic acid is passing to and fro over the surface during inspiration and expiration, the lead carbonate is probably converted into bicarbonate, dissolved and absorbed. Several years ago Alderson drew attention to absorption of lead by the respiratory organs as likely to induce more serious symptoms than when lead was introduced into the body by other channels. Goadby,* as the result of experiment, has arrived at a similar opinion: he maintains that "lead-dust circulating in the air is many times more dangerous than lead actually

* "Lead Poisoning and Lead Absorption," p. 98.

swallowed." The amount of lead-dust which reaches the lungs by inhalation must be small. The plumbism which follows inhalation of lead-dust may therefore be due not to lead having reached the lung, but caught in the mouth and throat or on any portion of the respiratory passages. That fine particles of lead carbonate can reach the lung there is no doubt. Laborde found that guinea-pigs exposed to an atmosphere in which white lead dust was suspended died within two hours, and that in the lungs there were small hæmorrhages, probably the result of irritation. On the other hand, Professor K. B. Lehmann of Wurzburg and his assistant Saito, notwithstanding the fact of the respiratory passages being the channel of entrance of the dust, found that only 12 per cent. of the lead reached the lungs, and that 70 per cent. was found in the alimentary canal. While penning these notes I examined, as stated earlier, two men employed in mixing red lead, salt-cake, and sand in a glass works. On the occasion of my visit they were wearing respirators, but they had evidently been just affixed, for on examining the mouth of one of the men who had only been a fortnight in the works, and who was ignorant of the risk he was running, I found a well-marked blue line on the gums, and in the other man, who had worked four weeks in the factory, there was not only a deep blue line on both gums, but on the teeth a bright red deposit of fine granules of the oxide of lead. These men were breathing an atmosphere which contained red lead dust, and while possibly some of it reached the lungs, the bulk of it was being caught on the teeth and in the mouth, where it would become dissolved in the saliva and swallowed.

Admitting that the lungs and the respiratory passages are frequent channels of entrance of lead into the system, I am of the opinion that it is by the alimentary canal, even when lead has primarily reached the upper part of the respiratory passages, that most of the poison enters the body. Reaching the stomach, it is acted upon by the hydrochloric acid of the gastric juice, whereby it is rendered soluble, and is absorbed unless proteid food is being digested at the same time, when only minute quantities of lead will be absorbed, the bulk of the poison being thrown out in the fæces. Soluble lead salts readily pass through any portion of the alimentary canal by osmosis into the veins, by which they are carried to the liver. This circumstance partly explains the fact of the liver containing considerable quantities of lead after death. The following histories and tables taken from my Goulstonian Lectures show the amounts of lead which Professor Bedson found in the internal organs of some of my infirmary patients who died from plumbism.

Elizabeth T., aged 22, single, had worked off and on during two and a half years in a white lead factory. At the end of the first three months she had to give up work on account of colic. On subsidence of the pain she returned to the factory, and worked seven weeks, when she was again obliged to desist on account of colic. Eleven months previously to coming under my care she had suffered from severe headache, followed by partial blindness. At this period she remained away from the factory for two months. On returning to work she again suffered from headache, also from pains in her joints, and her eyesight became worse. Urine was free from albumin. At the time of admission to the infirmary patient was menstruating. Patient died in a convulsion the day after being admitted. At the autopsy there was observed a blue line on the gums. The lungs were healthy; heart weighed $10\frac{1}{2}$ ounces, the wall of the left ventricle was slightly thickened, the valves were healthy, also the endocardium; liver and spleen were healthy. From the pelvis of the right kidney there escaped a few drops of a purulent-looking fluid, but there was no injection of the lining membrane, and the kidney substance generally appeared to be healthy, so too that of the left kidney. The interior of the uterus was covered with sanious material, probably menstrual. On examining the brain, the subarachnoid fluid was found to be excessive in the interpeduncular space and around the pons. The cerebellum was pale compared with the cerebrum. The surface of the brain was healthy, and the vessels were not unduly injected. On section the brain tissue was generally pale; there were few puncta hæmorrhagica; two to three drachms of serum in the lateral ventricles; the spinal cord was pale and hard.

CASE OF ELIZABETH T.

Name of Organ.	Total Lead in Parts per Million.	Weight of Organ.	Grains of Lead per Weight of Organ.
		Ounces.	
Lung	7·6	29·0	0·0964
Heart	4·12	10·5	0·0189
Liver	37·8	60·5	1·000
Spleen ...	12·0	6·5	0·0341
Kidneys ...	10·0	5·25	0·0229
Cerebrum ...	9·8	51·5	0·779
Cerebellum ...	24·8		
Pons	22·6	—	—
Spinal cord ...	1·16	—	—
Large intestine	37·7	—	—

Name of Organ.	Alcoholic Extract, Lead in Milligrammes.	Ethereal Extract, Lead in Milligrammes.	Aqueous Extract, Lead in Milligrammes.	Ash, Lead in Milligrammes.	Total Lead in Milligrammes.	Lead, Parts per Million.
Pons ...	0·14	0·35	0·0	6·1	0·59	22·6
Cerebellum ...	0·25	0·4	0·0	1·15	1·80	24·8
Cerebrum	0·3	0·0	0·0	1·35	1·65	9·8

The largest amounts of lead were found in the liver, large intestine, cerebellum, and pons. There is, however, no uniformity in regard to the distribution of lead in the internal organs, as the following table shows:

Case of Cath. H.

Name of Organ.	Total Lead in Parts per Million.	Weight of Organ.	Grains of Lead on Total Weight of Organ.
		Ounces.	
Heart	0·5	7·5	0·0016
Liver	41·6	45·0	0·819
Kidneys ...	13·3	4·5	0·0261
Spleen ...	39·0	5·0	—
Cerebrum ...	21·6	—	—
Cerebellum ...	8·59	—	—
Cerebrum and Cerebellum	30·19	48·0	0·634

Name of Organ.	Alcoholic Extract, Lead in Milligrammes.	Ethereal Extract, Lead in Milligrammes.	Aqueous Extract, Lead in Milligrammes.	Ash, Lead in Milligrammes.	Total Lead in Milligrammes.	Lead, Parts per Million.
Brain ...	0·6	0·6	0·91	1·3	3·41	21·6

The liver, spleen, and brain of Cath. H. contained the largest amounts of lead. In the brain of one of my patients Professor Bedson found the equivalent of 4·04 milligrammes of metallic lead, and in the brain of another 3·41. Mr. Wynter Blyth on one occasion recovered from the human cerebrum 99·7 milligrammes of sulphate of lead, and from the cerebellum 17·4. Gowers in his "Medical Ophthalmoscopy" mentions a case of Atkinson's in which 5 grains of lead were found in the brain.

The following table represents in milligrammes the amount of lead found in the organs of rabbits to whom lead carbonate had been given in food:

	A.	M.	S.	J.
Muscle	—	—	0·07	—
Liver	0·15	—	0·05	Trace
Small intestine...	—	—	—	—
Stomach ...	—	0·04	—	—
Heart	—	—	—	—
Brain	0·02	—	—	—
Large intestine	—	—	—	—
Kidney	Trace	—	—	—

In the case of rabbit M, which died from rupture of a pregnant uterus, it is interesting to note that while lead was practically absent in her tissues, it was present to the extent of 0·1 milligramme in the liquor amnii, and to the extent of 0·09 in each of the five fœtuses found in her uterus.

Symptomatology.

One of the earliest signs of lead intoxication is pallor. The face is not only pale but sallow. Fresh-coloured persons soon lose their ruddiness when working regularly in lead. Their facial expression, too, becomes altered. The blood becomes pale, thin, and watery, and the red corpuscles are diminished in number. Instead of there being 5 million red corpuscles per cubic millimetre of blood, they fall to 3½ million or less. The white corpuscles do not exhibit such aberration in numbers. By some lead workers the facial fulness and the body-weight are retained, but in others there is loss of flesh, which is slowly progressive up to a certain point, after which the bodily equilibrium is steadily maintained, it may be for months or years, without symptoms of plumbism. With the reduction in the number of red blood corpuscles the amount of hæmoglobin correspondingly falls.

The Blood in Saturnine Poisoning.

Medical opinion is divided upon the point of the anæmia of plumbism being the result of an active destruction of red blood corpuscles or of a lessened production. The somewhat pale urine passed in plumbism suggests deficient production of red blood corpuscles rather than a destruction of them. That the intracellular contents of red corpuscles are altered is shown by the punctated appearance presented by several of the erythrocytes when stained by certain reagents. Romanowsky's stains bring into prominence basophilia if it is present. In basophile degeneration a few of the erythrocytes show numerous minute bluish-black specks. The blood alteration to which Grawitz* and others have drawn attention is regarded by some physicians as a sign of importance in the diagnosis of lead poisoning. Before Grawitz drew attention to this subject Ehrlich, in 1880, had written upon basophilia in plumbism. As basophilia is not always present, even in cases of lead poisoning which are beyond question, and since, too, it is met with in diseased conditions which have no reference whatever to lead, the sign is thus to some extent shorn of much of its value. It is maintained that

* *La Semaine Médicale*, 1900, p. 40; also "Klinischer Patholog. des Blutes," p. 86.

if basophile red corpuscles are present in a film of blood to the extent of over 100 per million of red corpuscles, this is positive proof of the existence of lead poisoning. M. J. Schönfeld * states that by the detection of basophilia alone he is able to place according to risk the various occupations which expose the workers to saturnism. He does so in the following order: colour lithography, type founding, colour mixing, house painting, electro-accumulator making, file cutting, metal polishing, and stereotyping. Compositors follow closely upon the latter. Of 185 compositors, Schönfeld found that only 20 gave a positive reaction. Dealing with this subject, he makes the following remark: While compositors are the victims of plumbism in small numbers, the men are so preoccupied with their symptoms that, owing to their nervous tension, when the slightest illness develops there is created in them a condition bordering upon saturnine hysteria, so that they consult a doctor with their diagnosis of lead poisoning self-made. Schönfeld therefore regards a negative basophilia in compositors as most important, for he makes use of the fact to encourage the men that they are not suffering from plumbism. This writer omits from his classification of trades likely to give rise to plumbism lead

* *Medizinische Klinik*, May 18, 1913.

smelting, the cleaning of flues, and the manufacture of red and white lead. Possibly he was not so favourably situated as to have the opportunity of observing the harmful effect of these trades. Professors Hoffman and Schmidt of Leipsic, maintain that the presence of 100 basophile erythrocytes per million red blood corpuscles in the blood of a person working in lead ought to be occasion for the factory doctor to watch such a workman from a health point of view, and that any person whose blood showed 300 per million should be at once suspended from work in lead. This opinion has been accepted by the authorities in Leipsic and by the State as the basis upon which suspension from work should be enforced. At the Institute of Hygiene, Leipsic, 1,031 blood examinations were made between the years 1907 and 1912. Basophilia was found in 187 instances —*i.e.*, in 18·1 per cent. Dr. John Russell * in 100 consecutive examinations of persons receiving compensation for lead poisoning in the Stoke-on-Trent area found that 27 exhibited no blood changes, 26 showed basophilia under 300 per million, and that 47 showed granular degeneration ranging from 300 to 27,000 per million. It is to be remembered that in other pathological conditions such as nitrobenzene and aniline poisoning,

* *British Medical Journal*, January 7, 1914, p. 143.

and in some forms of bloodlessness such as pernicious anæmia and malaria, basophilia may be present, and that it is occasionally present in the blood of healthy persons who have not been brought into contact with lead (Teleky).

It would be idle, in face of the strong evidence thus advanced, to attempt to depreciate the extent or the meaning of basophilia in plumbism. In the North of England basophilia is not so frequently met with in lead-poisoned persons, as in the Midlands, London, and on the Continent. In some of my patients the degeneration has been detected by means of the various aniline stains recommended by writers upon the subject, but in by far the majority of cases—at least 75 per cent.—it is absent. The greatest care has been taken in the preparation, staining, and examination of the blood films. These films have been examined by competent pathologists, not only in the North of England, but elsewhere by pathologists of repute, with the result that even in the blood of well-marked cases of plumbism basophilia was not found. For these and other reasons basophilia has not to me the diagnostic importance which several British and Continental physicians claim for it.

Ludwig Teleky* of Vienna has reviewed this

* "Die Ärztliche Überwachung und Begutachtung in der Bleitrieben beschäftigten Arbeiter." Berlin: A. Seydel, 1912.

subject at considerable length. In addition to Grawitz, Messrs. Behrend, Hamel, Moritz, and Embden maintain that basophilia is one of the first diagnostic signs of plumbism, and that it is present in workmen who have not yet begun to complain of symptoms of plumbism. P. Schmidt, in drawing the line between normal and pathological basophilia, says that if 100 punctated erythrocytes per million red corpuscles are present, upon this circumstance alone a diagnosis of plumbism may be made, and that by detecting the malady in this early stage the more serious forms of lead intoxication may be averted. Personally, I could hardly recommend the suspension from work in a lead factory of any person whose erythrocytes showed basophile granules. Basophilia is not of itself a disabling circumstance. Lutoslawsky, in 1902, found in 107 persons suffering from chronic plumbism only 17 in whom there was no basophilia. On the other hand, Biondi, at the 1906 Congress of Industrial Diseases, Milan, stated that he had not found basophile red corpuscles in the blood of persons suffering from severe lead intoxication.

In order to determine the value of basophilia in plumbism from a diagnostic point of view, Teleky submitted the matter to the following test. Securing the assistance of Dr. Alfred Götzl, it was arranged that an examination of the blood of all persons coming to Dr. Teleky suffering from lead poisoning was to be made, the agreement being that Teleky was to take a note of the history of each patient, to prepare the film of blood, and to make a diagnosis without knowing what a microscopical examination of the stained blood revealed. Götzl was to examine the films for basophilia, and only after he got his results together was he to be informed of the history of the cases. In this way Götzl's examination was purely objective. The blood was taken on the occasion of the first visit of the patient to Professor Teleky, and in a few instances subsequently. In all 202 blood examinations were made of 154 persons. Of 79 patients who showed a blue line on the gums, also saturnine cachexia, and who, in addition, were complaining, no degenerated erythrocytes were found in 25; in 13 of these 25 not even after repeated examination, and in 12 after only one examination. In 37 of 44 patients without blue line but with cachexia no basophilia was found; in 19 of 22 patients with a suspicious blue line and mild cachexia no basophilia was detected; and in 4 of 9 patients with a blue line and without cachexia there were no degenerated red blood corpuscles.

In 546 lead workers, P. Schmidt found basophilia absent in 72·9 per cent.; in 17·9 per cent. there were 100 basophiles per million red corpuscles, and in 9·2 per cent. over 100 per million. Meyer and Speroni found in lead-poisoned persons basophilia present one day and absent another. Basophilia occurs in post-hæmorrhagic anæmia, especially if the bleeding has been internal. Otto Nageli * considered that in these cases the basophilia stood in direct relation to the absorbed hæmoglobin. During the administration of arsenic to a child suffering from pseudo-leukæmia the number of basophile corpuscles in the blood rose from 1,100 to 17,160 per cubic millimetre of blood. Nageli found basophile corpuscles in 21 per cent. of healthy persons, and that their number increased after a meal of black pudding. Even when lead is present in the urine basophilia may be absent in the blood. To insist that a case is not one of plumbism unless there is basophilia is to assume a position which experience and the facts recorded above do not support.

In a large number of patients, therefore, in whom one would expect to find the earliest signs of lead poisoning basophilia is absent. It is hardly true, therefore, that the earlier the stage of the intoxication the more sure you are to find basophilia. I did not find punctated red corpuscles in the blood of a laboratory rabbit which had taken,

* "Blutkrankheiten und Blutdiagnostik." Leipsic: Veit and Co., 1912, p. 155, etc.

in the course of three years, 1,095 grains of nitrate of lead, nor was it present in fully three-fourths of my patients who were the subjects of diachylon poisoning, and in whom there were blue line on the gums, paralysis, and in whose urine lead was present. The patients in whom I have found basophilia were less frequently in the early than in the late stages of the malady. Many physicians, however, find basophilia a sign of great importance in the diagnosis of lead intoxication.

One point concerning basophilia which must not be lost sight of is that the technique involved in the preparation and staining of the blood, also the care required in scrutinizing the field under high magnifying powers, render the procedure one which can hardly be undertaken by men in busy medical practice. Under these circumstances films of blood should be sent to one of the Pathological Research Societies, of which there are now several in the country.

The actual nature of the granules seen in basophile red corpuscles is not quite known. Some writers regard them as signs of degeneration, other authors believe them to be regenerative. I have tried several methods* of staining

* Dr. Glibert, Brussels, uses as a staining agent the following: Methylene blue, 2 grammes; soda bicarbonate, 12 grammes; and distilled water, 200 grammes. The film of dried blood is steeped in absolute alcohol for half an hour and the film is kept in the staining solution one minute.

blood for basophilia. Hamel recommends the following: Take a film of blood from the cleansed lobe of the ear of a patient, dry the film in the air; fix the blood for three to five minutes in absolute alcohol; wash in water, and when the slide is still wet pour upon it a few drops of Loeffler's methyl blue. Shortly afterwards the slide is washed in water, when it ought to show a light blue stain. If it is too light it can be stained again with Loeffler's blue. It is advisable not to stain too deeply, otherwise the granules cannot be distinguished. The film is dried between blotting-paper, and warmed for a moment over a flame in order to dry it completely. The effect of the heat is to change the light blue into a light green stain. Under an oil-immersion lens the nucleus of the white corpuscles is seen to be deep blue, while the rest of the contents are pale and colourless. The erythrocytes are light green, and in those which have undergone basophile degeneration dark blue granules may be recognized. Polychromophil erythrocytes must not be mistaken for basophiles. In them the staining is not granular but general.

In health the red blood corpuscles vary in size, but in plumbism there is no well-defined alteration in size or shape of corpuscle peculiar to the malady, or which can be regarded as pathognomonic of lead poisoning.

The number of white corpuscles in the blood varies. In some patients there is a moderate leucocytosis, in others there is a leucopœnia. The leucocytes which stand out most prominently on the stained field are sometimes polymorphonuclears, in other instances lymphocytes are more in evidence. As to why there should be in one patient polymorphonucleosis and in another lymphocytosis I can offer no opinion. Occasionally eosinophile corpuscles are present in slight excess.

Blue Line on the Gums.

Next to anæmia and pallor of face, one of the early signs of plumbism is the presence of a blue line in the mouth close to the margin of the gums and running up in the processes between the teeth. The depth of the colour varies. It is sometimes bluish-black or a light slaty-blue. Although usually more pronounced in persons with decayed teeth and unhealthy gums, also in those who do not keep their teeth clean, I have seen it in persons with dentures clean and well preserved. For its development it is not necessary to have a preceding gingivitis. It is common experience that in lead workers who brush their teeth and who rinse the mouth preparatory to leaving the factory, the blue line may be absent. In consequence of a more careful personal hygiene and greater attention to regulations, a blue line on the gums is less frequently observed in lead workers than was the case a few years ago. When examined with a lens the blue line exhibits a punctated appearance. On the whole the line is found more frequently on the lower than the upper gum, and it is absent where the teeth have been removed. On one occasion the presence of a well-marked blue line on the red matrix of an artificial set of teeth was of considerable assistance to me in making a diagnosis of lead poisoning in a female patient of Dr. Walker, Hebburn-on-Tyne. The patient was the subject of an obscure form of nervous disease, accompanied by paralysis of the muscle of the eyeball. The diagnosis of plumbism was confirmed by detecting lead in the urine.

In lead workers engaged in a dusty process, a blue line may be observed on the teeth or on the margin of the gum close to the teeth. This is simply a deposit of sulphide of lead. By swilling the mouth with warm water, and by friction with a toothbrush, such a blue line will almost at once disappear. The true Burtonian or characteristically blue line of plumbism is not so readily removed, for it is due to a deposit of particles of lead sulphide inside the cells of the deeper layers of the gum. Probably a soluble lead salt in the mouth has been absorbed by the cells, and changed into sulphide by the action of sulphuretted hydrogen generated by decomposition of particles of proteid food left between the teeth, by the action of the sulphur in the sulphocyanide of potassium present in the saliva, or the blue line is the result of phagocytic cells of the gum taking up and retaining particles of lead.

Ruges has advanced the theory that the blue line is due to lead albuminate, which has escaped from the capillaries of the gum, and become converted into sulphide by the action of sulphuretted hydrogen in the mouth. It should be remembered that lead albuminate is not very soluble, nor does it osmose readily. That the lead which is deposited in the gums can be carried thither by the blood from the tissues is confirmed by experience such as this—where in the case of a lead worker absent from the factory for a few months, and in whom there was no blue line on the gums, there developed, as the result of the administration of potassium iodide, not only double wrist-drop, but a blue line on the gums as well.

The edge of the gum is usually abraded. In older workmen the gum may be ulcerated. In consequence of loss of substance and recession of gum, a greater length of the fang of the incisor teeth is shown than is the case in a healthy mouth. Just inside the lower lip, or on the inside of the cheek opposite a decayed tooth there may be observed a bluish-black patch, irregular in outline, and varying in size from a three-penny-piece to a sixpence. In an ordinary way where this patch is present it is usually persistent. That it is due to infection by friction against a decayed tooth is confirmed by the fact of the patch disappearing if the tooth is removed, and of another patch developing on the inside of the other cheek opposite a tooth which has become coated with tartar. A blue line on the gums with difficulty distinguished from that caused by lead, may be observed in persons to whom large doses of bismuth have been administered by the mouth, or who, as the subjects of empyema, have had injected into the fistulous track in their thoracic wall, bismuth emulsion. A blue line on the gums, with a greater degree of shading away from the margin than occurs in plumbism, may be met with in persons who have used charcoal as a toothpowder. The particles of carbon can be extracted by a fine needle. Close to the teeth on the gum of a coal-miner, my colleague, Sir George Hare Philipson, found a persistent black line due to particles of carbon. On the gums of men and women who are engaged in making up a blue bed in a white lead factory, a brown line may be observed due to the fine dust of the tan. This line, however, has no permanence. On the teeth of men working in copper, a greenish line may be observed. In cases of pyorrhœa alveolaris, the gums may exhibit a slight blue discoloration. Not only are the gums and the inside of the cheek discoloured in plumbism, but the tongue may become bluish as well.

The presence of a blue line on the gums must not be taken as an indication that its owner is suffering from lead poisoning. If not readily removable by a toothbrush, it is a sign that lead is in the system, and that no person who exhibits a well-marked blue line can be said to be absolutely free from the possibility of symptoms of plumbism developing. Accompanied by other symptoms it is a valuable sign.

Colic and Constipation.

Colic and constipation are early symptoms of lead poisoning. These may be preceded for days or weeks by an unpleasant metallic taste in the mouth, by loss of appetite, and by a distaste for food. I have known a young lead worker bring home in the evening, untouched, the meals she had taken to the factory in the morning. A circumstance such as this is a clear indication that things are going wrong. It was so in this particular instance, for convulsions unexpectedly developed, which proved fatal within a few hours.

Colic may be so severe that the patient cannot allow of any pressure being made upon the abdomen. In other instances relief is obtained by the patient placing a pillow on the back of a chair, and pressing the abdomen upon it. So severe sometimes is the pain, that the patient can hardly be kept in bed. During pain, the abdomen is hard and retracted: the face wears an anxious expression. Vomiting occasionally accompanies the pain. The pulse-rate falls: it is small, or it may feel hard and feeble, and there may be only twenty to thirty beats per minute. Riegel found that the pulse in lead colic exhibited high tension. He was of the opinion that colic might be due to intestinal spasm, following constriction of the arteries in the splanchnic area. Such high blood pressure is not an invariable accompaniment of colic. The amount of urine passed during the attack of colic is scanty; frequently it is not more than 4 to 6 ounces in the twenty-four hours. The cause of lead colic is obscure. Setting aside the arterial constriction just mentioned, also irritation of the solar plexus, which Harnack claims that lead is capable of causing, I have found in animals who have died from acute lead poisoning the intestinal canal irregularly contracted in places: over a length of 2 to 3 inches it would be so firmly contracted as to have its calibre completely obliterated, so that while the pain might be explained by this severe muscular spasm, it might also be the result of the upper portion of the intestine contracting and making an effort to propel its contents into the constricted portion below. The pain is mostly referred to the neighbourhood of the umbilicus. It can hardly be due, as Traube taught, to violent intestinal peristalsis set up by an accumulation of hardened fæces, for pain may be present when there is no constipation. On subsidence of the acute pain there may still linger for several days considerable tenderness revealed by pressure upon one side or other of the abdomen, the interesting point being that this unilateral tenderness is associated with inequality of the pupils, inequality of the radial pulses, also with greater pain on one side of the neck than the other on pressing upon the course of the vagal nerves. The inequality of the pupil suggests irritation of certain strands of the abdominal sympathetic system of nerves. There may be also unilateral sweating of a portion of a limb—*e.g.*, one hand.

During colic sulphocyanide of potassium is usually absent from the saliva. On the addition of a weak solution of liq. ferri perchlor. to the saliva, the reddish-brown coloration, characteristic of the presence of sulphocyanide, is not obtained, but it will be found after disappearance of the abdominal pain.

In women who have taken diachylon, pain may be referred to the pelvis; it is aggravated on pressure, and on vaginal examination the uterus and adnexa are found to be tender on pressure.

Sometimes the abdominal pain is referred to the ileo-cæcal region. Lead colic has been mistaken for appendicitis, and patients have been operated upon for supposed appendicitis when the case was one of acute plumbism. One of my hospital patients was primarily admitted into the surgical ward to be operated upon for what appeared to be intestinal obstruction. There were absolute constipation, severe abdominal pain, fæcal vomiting, and low temperature with signs of collapse ; but as there were also retraction of the abdomen, a blue line on the gums, and albumin in the urine, the patient was not submitted to operation. He died two days afterwards from uræmia due to plumbism: at the autopsy the kidneys were found to be atrophic, and there were no evidences of intestinal obstruction. There is no reason why a lead worker should not suffer from appendicitis like other people, but the history of the occupation of the patient and a careful examination of the abdomen as to the seat and character of the pain as well as of the outline of the abdomen generally should cause us to hesitate, and not with undue haste rush into an operation. It is rare for a patient to die in acute lead colic, but the event is possible. Although obstinate constipation is the usual accompaniment of lead colic, in some instances there is diarrhœa. Removal of the constipation in plumbism is not always followed by immediate relief to pain.

Types of Industrial Plumbism.

Owing to improved methods of working, periodical medical examination of the workers, and greater attention to regulations, the type of plumbism met with nowadays is usually subacute or chronic. The acute type, that known as saturnine encephalopathy, is less frequently met with than twenty years ago. Two decades ago it was a frequent mode of death, particularly in female lead workers. It was the high mortality from this cause that induced me to recommend to the Home Office the abolition of female labour in the dangerous processes of white lead factories. Acute plumbism may be the result of an accident, as in the case recorded of a labourer, who when carrying a barrel of red-lead, allowed the barrel to fall. Almost immediately he was enveloped in a cloud of red dust. Some of this was inhaled: the dust settled in his nose and throat, in his eyes and ears, also in his hair, and, as a result, symptoms of acute plumbism developed.

HEADACHE.

A large percentage of lead workers, when ill, complain of headache. It is characteristic of the headache of plumbism that the pain is extremely severe. It respects neither sex nor age. In the absence of albumin in the urine, and of anatomical changes in the retina, but with a history of exposure to lead, headache is of diagnostic importance. The pain is not confined to any particular part of the head: it is located more frequently in the vertical and occipital regions. There is a type of saturnine headache which is rather suggestive of neuralgia, since it is referred to the frontal region, and is associated with arterial spasm. Sometimes albumin is found in the urine and sometimes not. The headache, although of toxic origin, is not always uræmic. Severe headache may be followed by delirium. This may pass off in the course of a few days, or it may persist and gravitate into acute mania, the aberrant mental condition being preceded by loss of sleep. A maniacal outburst is frequently attended by a rise of temperature. Instead of delirium, severe headache may be the forerunner of convulsive seizures. The twitchings commence in one half of the face, extend to the arm and leg of the same side, after which the convulsions become general. The fits are attended by loss of consciousness. The development of convulsions in a lead worker is of serious significance. The muscular movements are not always of uræmic origin, for I have seen them occur in lead workers in whose urine there was no trace of albumin. The convulsive attacks constitute what is known as *saturnine encephalopathy*. In some of my patients the attacks have been preceded by such indications of nervous folly as alternate laughing and crying, symptoms suggestive of hysteria; but this form of toxic hysteria must not throw the medical attendant off his guard, for too frequently it marks a deeper and more severe affection of the nervous system than at first sight appears. Within two to three days after an outburst of saturnine hysteria the patient may be dead, the fatal termination having been preceded by convulsions. At the autopsy, all that may be observed are a dry surface of the brain, flattened convolutions and constricted bloodvessels; the whole brain looks as if it had been compressed, and judging from its pallor it would appear as if during life there had been considerable pressure consequent upon widespread spasm of the cerebral arteries.

So closely do the brain symptoms in plumbism resemble those of cerebral tumour—viz., severe headache, vomiting, one-sided convulsions with or without retinal changes—that the cerebral type of plumbism has been mistaken for tumour of the brain. I have known of patients trephined for suspected cerebral tumour when the case was one of lead poisoning, in whom after death the vascular changes in the brain were those purely reactionary to the operation, and in whose brain and internal organs lead was subsequently found. In such cases before operating assistance might be obtained in framing a diagnosis by an examination of the urine for lead.

Saturnine encephalopathy is the most serious form of plumbism. The convulsions keep recurring. After a patient has lain in a state of coma for two or three days, consciousness may return, but it may be with eyesight lost. On examining the eyes by the ophthalmoscope, retinal hæmorrhages or acute neuro-retinitis may be found. Vision may be permanently lost, or it may be slowly regained, but never quite completely. Saturnine encephalopathy is fortunately becoming much more rare among lead workers.

Plumbism and Loss of Vision.

The relationship of working in lead and loss of vision is threefold. There is a loss of sight in which no structural changes are observed in the fundus oculi; this is probably of toxic origin, and due to a functional condition of the nerve cells in the deeper visual centres of the brain, associated possibly with spasm of the bloodvessels leading thereto, for the amblyopia is transient and rapidly disappears. Elschnig * found in a patient who was suffering from lead colic, and who had suddenly developed amaurosis, spasm of the small arteries of the conjunctivæ and retinæ. The spasm seemed to Elschnig to be the localized result of a widely distributed action of lead, not only upon the musculature of the bloodvessels of the eye, but also upon the arteries supplying the muscles of the eyeball. There occurred paralysis of the muscles of accommodation with dilatation of the pupil. In the other forms of blindness there are structural alterations in the disc and retina. When blindness follows headache and convulsions the discs are hyperæmic, swollen, and mottled, the borders are ill-defined and irregular, the bloodvessels in places are obscured, delicate white striæ lie external to them in their course, the veinules are distended, and hæmorrhages may be observed in the retinæ. These ophthalmoscopic changes are characteristic of saturnine encephalopathy, and they may be found in young lead workers who have been in a factory only a few months. Should the patient recover from the convulsive seizures vision is never

* *Wien. Med. Wochenschr.*, 1898.

quite regained, for the hæmorrhages may never be entirely absorbed, and the discs may atrophy. Such intra-ocular changes as those just described may occur in lead workers whose urine is free from albumin, but in the third form of blindness the patient may be the subject of kidney disease. It is the second form which is characteristic of saturnine encephalopathy. How the intra-ocular changes are brought about it is difficult to say. It is maintained by some physicians that lead acts mechanically: by inducing effusion into the sub-arachnoid spaces of the brain it is believed to cause distension of the sheath of the optic nerve. Amenorrhœa is considered to be a predisposing cause, but as the eye-changes occur in males as well as in females, and of the latter especially in those who have been the subjects of menorrhagia, clearly this cannot be the cause. In one of my patients who died in the acute attack not only was the surface of the brain flattened as if compressed, but there was also a small quantity of serous fluid in the ventricles. On section of the optic nerve, while the central bloodvessel appeared to be healthy, there was found on microscopical examination round-celled infiltration of the fibrous trabeculæ between the bundles of nerve fibres, the infiltration being most marked at the posterior portion, and for some distance behind the lamina cribrosa. The disc was swollen. In the body of a lead worker who has died from saturnine encephalopathy the brain signs may be negative; in another, in addition to pallor, there may be fewer puncta hæmorrhagica than usual, and only a dram or so of fluid in the lateral ventricles. Dr. Mosny, of the Hôpital St. Antoine, Paris, found in the brain of persons dying from acute plumbism with nervous phenomena small hæmorrhages in the cortex of the brain. Similar minute hæmorrhages have been found in the brain of animals the subjects of experimental lead poisoning. Dr. F. W. Mott found on microscopical examination miliary hæmorrhages in the perivascular sheaths of the small vessels of the cortex and of the substance of the brain in a coach painter who had had epileptic seizures. Goadby,* in his experiments upon animals which had inhaled lead dust, found minute hæmorrhages at the base of the brain and over the vertex. "Minute hæmorrhages were found often underneath the arachnoid membrane, but the largest hæmorrhages were always found at the base of the brain and spreading down into the spinal canal along the medulla."

* "Lead Poisoning and Lead Absorption," p. 192. Legge and Goadby.

Nervous System.

The cells of the central nervous system and the fibres of the peripheral nerves are prone to be affected by lead, and this not only by lead compounds directly introduced into the body, but also by the liberation and re-solution of organic lead combinations which had been stored up in the system, and were not causing symptoms. Such occurrences take place in persons who are the subjects of chronic plumbism; also in women who have taken diachylon there are these ingravescent periods. It would seem as if now and again there passed over the system waves of poisoning owing to reabsorption of minute quantities of lead which had been deposited in the intestinal canal or elsewhere. Some lead workers complain of a gradual weakening of the muscular power, especially of the hands and wrists. A cooper in a lead factory, for example, may find as one of the earliest symptoms that he cannot grip or use the hammer as well as formerly. Such paresis may gravitate into paralysis. In a large number of patients loss of power in both hands develops without there having been colic. Between night and morning a lead worker, after or without premonitory symptoms, may develop double wrist-drop. Only occasionally is the paralysis preceded by pain in the muscles and nerves. The fact that both hands are usually affected suggests that a general cause such as a poison has been in operation, but the wrist-drop may be present on one side only, or if it is double it is observed to be more pronounced on one side than the other. Dr. Ludwig Teleky is of the opinion that the paralysis of lead poisoning affects with greater severity the muscles which are most used by a person in his occupation. He considers fatigue to be a contributory cause. The fact of certain muscles being more profoundly involved in lead poisoning compared with others would thus be partly explained by the occupation the individual had followed. The theory which held that the muscles affected are those immediately under the skin, through which at particular parts of the body absorption of lead might have taken place, has few adherents. In the case of file-cutters the muscles of the fingers of the left hand, since they grip the chisel, suffer more than those of the right hand, which raises the hammer. During the striking of the chisel, the left hand rests more upon the lead cushion, but notwithstanding this there is greater and more continuous strain of the fingers of the left than of the right hand. In the case of house and coach painters, owing to the manner in which the brush is held, the right index finger and thumb suffer most. In a street lamp-lighter suffering from plumbism I found only the muscles of the right hand affected—viz., those concerned in pronation and supination. Goadby, adopting the teaching of Edinger and Teleky, maintains that the paralysis of lead poisoning is in some way associated with previous muscular strain, and that it is influenced by the relative weights and volumes of the muscles of the hands and forearms. He considers that previous exertion plays a part in locating the paralysis. Goadby found in experimental plumbism, as the result of rupture of small bloodvessels, minute hæmorrhages in groups of muscles which were functionally related. Since certain groups of muscles are made use of in some trades more than others, it is maintained that as greater stress is thrown upon these muscles during work, not only does this circumstance determine the hæmorrhages but it explains also the paralysis. On microscopical examination minute extravasations of blood may also be seen in the nerves which supply the paralyzed muscles.

Weakness of the wrists, with or without tremor, is an early sign of plumbism; it is frequently a forerunner of paralysis. The extensor muscles of the wrists, the interossei, the common extensor of the fingers, and the extensor of the forefinger are among the first muscles to become paralyzed.

When the loss of power is complete, patient is unable to extend the wrist. Any attempt to do so or to straighten the fingers is followed by a quivering and a drawing inwards of the semi-flexed and helpless fingers towards the palm of the hand. Notwithstanding this loss of power, the hand can still be pronated and supinated. The muscles which are paralyzed are innervated by the musculo-spiral The supinator longus muscle, although supplied by the same nerve, is not paralyzed, partly owing to its size, and the fact that it belongs to the flexor group, and is innervated from another source in addition to the musculo-spiral.

Three or four different types of lead paralysis are met with. They are more or less classical, but patients often seek advice for loss of muscular power when the paralysis does not conform to any definite type. In a general way it may be said that in the largest number of instances the paralysis affects the extensors of the fingers, thumbs, and wrists. The extensor and abductor muscles are always more readily affected than the flexors and adductors. Considering their volume, the muscles of the fingers have much work to do. Paralysis of the muscles just mentioned takes place independently both of the channel by which lead gains an entrance into the body and of the kind of occupation the patient has followed.

Remak described a form of paralysis—the brachial type—in which the muscles affected are the deltoid, biceps, brachialis anticus, and supinator longus, the so-called Duchenne-Erb group, with frequently the supra- and infra-scapular muscles as well. In this type the deltoid is the muscle first affected, and it alone may be involved; in other instances the supinator longus may alone be paralyzed. When the deltoid is affected, the arm hangs loosely by the side of the body—it cannot be raised; the humerus is rotated inwards, and the arm is semi-prone. In the commonest form of lead paralysis, where the extensors of the wrist and fingers are involved, the antibrachial, or Déjerine-Klumpke type, the supinator longus is not affected; in the first form supination is impossible owing to implication of the supinator brevis. In the second type the extensors of the index and little fingers become paralyzed: so, too, the long extensor of the thumb. The hand droops in a semi-prone position, hence the term "wrist drop" applied to it. There is another form of paralysis, the Aran-Duchenne type, mostly confined to the small muscles, the outer borders of the hand, and those of the thumb and interossei. The hypothenar and the thenar eminences lose their fulness, and the interosseal grooves deepen. Atrophy, which is generally pronounced, accompanies the paralysis. There is usually also fibrillary tremor, so that the hand resembles that observed in progressive muscular atrophy. While lead paralysis affects with greater frequency the muscles of the upper extremity—a circumstance which roughly distinguishes it from loss of power due to arsenic and alcohol—yet the muscles of the leg may become involved, giving rise to the peroneal type of lead paralysis, in which the peronei muscles and extensors of the toes are affected, the tibialis anticus, like the supinator longus in the forearm, escaping. The peroneal type of lead palsy is usually preceded by such prodromata as pains in the legs, with a sense of numbness and tingling, or there is hyperæsthesia. Tancquerel states that this type of paralysis forms 13 per cent. of all the cases. This percentage is overstated so far as Great Britain is concerned. The peroneal type of lead paralysis may occur alone, it may accompany the loss of power of hands and wrists, or be part of a wider distribution of loss of power, in which the psoas and other muscles connected with the pelvis are involved. In young children lead paralysis affects particularly the lower extremities, probably because children run about more than adults, and, on Edinger's theory, their muscles would be more exposed to fatigue, and therefore more likely to be influenced by lead.

In addition to paralysis of hands, forearms, and legs, the loss of power may be widely distributed, so as to involve more completely, not only the bulk of the muscles of the limbs, but those of the back as well. Such a general and widespread distribution of paralysis occurred in one of my patients within twenty-four hours. The woman lay in bed like a log, unable to move or to help herself. The intercostal muscles became affected, so that respiration was carried on with difficulty. Usually in this form of paralysis the muscles of the head and neck are respected. This widely distributed paralysis is admitted to be extremely serious, yet in the two instances in which I have seen it both patients recovered. Four years afterwards one of them gave birth to a living child. Although in these cases it is exceptional for death to take place from asphyxia, as sometimes occurs in acute ascending paralysis, yet Strauss and Heugas* have published the details of a case in which death was due to respiratory paralysis. The muscles of the larynx occasionally become affected; so, too, those of the bladder. In some of the less usual forms of plumbism the muscles of the eyeballs are paralyzed. There may be ptosis or diplopia; the pupils may be unequal. In a young married woman, aged twenty, who had taken diachylon to induce abortion, I found

* Heugas, "Contributions à l'Étude de la Paralysie Saturnine," p. 54.

paralysis of the external rectus muscle of each eyeball, more pronounced in the right than the left. There was double neuro-retinitis, running on to atrophy of the disc. Here and there in the fundus were minute hæmorrhages. During the time patient was under hospital observation she was almost completely blind. She had taken only a small fraction of a pennyworth of lead oleate. She never had colic, only severe headache; no vomiting. Lead was never found in her urine. There was a deep blue line on the gums.

Sensory Symptoms.

Pain may precede the various forms of paralysis met with in lead poisoning, but once muscular power is lost pain is not a prominent symptom unless in patients whose legs are paralyzed. In wrist-drop there can occasionally be detected patches of analgesia and anæsthesia on the inner and posterior aspects of the forearm. On the leg similar patches may be found when the lower extremities are involved. In females, the loss of sensation may be such as to suggest a hysterical or functional origin of the anæsthesia; but if the skin is pricked blood fairly readily flows, showing that there is none of the ischæmia which is a feature of the hysterical state.

Tremor is an important sign of plumbism. It affects mostly the hands, head, and neck. A localized tremor can be brought into evidence in lead workers who are not ill, in whom there is nothing but pallor, with or without a blue line on the gums, by asking them to show their teeth. The action is accompanied by well-marked tremor of the naso-labial fold of muscles. In patients the subjects of chronic plumbism, and whose speech is slow and syllabic, there is sometimes tremor of the tongue when it is protruded. The tremors are, if anything, coarser than those observed in persons suffering from general paralysis. Where there is wrist-drop the tremor may only affect the fingers. In one man, when the hands were outstretched, tremor always commenced in the left thumb, and gradually extending up the arm, the whole limb became so violently agitated that the movements passed beyond the control of the patient.

Of the mental symptoms which are occasionally observed in lead poisoning, mention may be made of acute delirium. This may develop independently of convulsions or coma, and it may be unattended by a rise of temperature. In one female patient the delirium was accompanied by fever, but she was the subject of acute mania and had to be removed to an asylum. Lead poisoning is a cause of delusions. Years after the attack the patient informed me that when the severe pain in her head subsided, she was under the impression that she had received a message to go to America.

About midnight one evening she was found by the police patrolling the deck of a steamer lying in the Tyne. After a few months' residence in an asylum she recovered, was discharged, and there has been no recurrence of her mental symptoms.

Saturnine Pseudo-General Paralysis: Wassermann Reaction.

In some of my male patients the symptoms have resembled those met with in general paralysis. There are slow and interrupted speech, fibrillary tremor of tongue, also of naso-labial muscles, defective memory, inequality of pupils, slight staggering in walking, and exaggerated or absent knee-jerk, but there are none of the exalted ideas nor of the irascibility of temper which are prominent symptoms of the classic type of general paralysis. Besides, whilst recovery may take place in the saturnine form of the malady it is not known to occur in the other. A lead worker who has incurred the risk of catching syphilis is equally liable to general paralysis like other men. In the brain of one of my lead patients who had presented symptoms of general paralysis there was found at the autopsy meningitis with subarachnoid effusion in the neighbourhood of the fissure of Rolando. Although no history of syphilis was obtainable, the character of the brain lesion rather suggested that such a disease had existed. I have tried the Wassermann reaction in many patients suffering from plumbism. I have found it positive both in male and female patients.

The resemblance of saturnine pseudo-general paralysis to the ordinary and better-known type calls for comment owing to the fact that in both diseases there is the same tendency for the bloodvessels to become affected at a comparatively early age, for the membranes of the brain to become occasionally involved, and also on account of the response to the Wassermann test. At a meeting of the Société Médicale des Hôpitaux, Paris, February 20, 1914, Messrs. Oettinger, Pierre-Louis, Marie, and Baron raised the question of the association of Wassermann's reaction and plumbism. The patient, who was a red lead furnace-man, aged thirty-three, and who denied syphilis, had suffered from colic and from pains in the arms and shoulders; there were, in addition, muscular atrophy and mild basophilia. Both the blood and the fluid removed from the spinal cord by lumbar puncture gave a positive Wassermann reaction; the spinal fluid showed hyperalbuminosis and leucocytosis. Eleven days after having been treated by sulphur baths and sulphur administered internally there was, on examining the spinal fluid, no longer any lymphocytosis.

The amount of albumin in the spinal fluid had diminished, while both of it and the blood a Wassermann test was negative. Patient made a good recovery. The fact of a positive Wassermann reaction having been obtained on the first occasion raises the question as to whether there was latent syphilis to explain the character of the meningeal fluid, but the fleeting nature of the reaction and the early return of the spinal fluid to its normal were regarded as rendering untenable this supposition. Dreyer,* out of thirty-five cases of plumbism obtained positive Wassermann reaction in four. Schnitter † obtained positive Wassermann reaction in four out of fourteen men who had worked in lead and who were the subjects of chronic plumbism. As in none of these men syphilis could be confirmed he insists upon the non-syphilitic character of the reaction in saturnine intoxication. Cyrus Field ‡ obtained positive Wassermann reaction in the blood of five out of twelve lead-poisoned patients. Oettinger, Marie, and Baron induced lead poisoning in six guinea-

* "Ueber die W. R. bei Bleivergifteten," *Deutsch. Med. Woch.*, 1911, No. 17, p. 786.

† "W. R. bei Bleivergifteten," *Deutsch. Med. Woch.*, 1911, No. 22, p. 1030.

‡ "The Occurrence of a Positive Wassermann Reaction in a Case of Lead Poisoning," *Journ. Amer. Med. Assoc.*, 1913, No. 22, p. 1681.

pigs by means of acetate of lead introduced into the body by various channels without obtaining in one single instance a positive reaction, no matter the stage of the intoxication and the presence of basophilia. Schnitter holds that the Wassermann reaction bears a relation to the number of basophile corpuscles present in the blood, but in this opinion he is not supported by other physicians, nor did the experiments on guinea-pigs just referred to support the statement. According to Oettinger, Marie, and Baron a positive Wassermann reaction obtained in the course of saturnine intoxication does not allow us to conclude that it points to a syphilitic origin. Sicard and Bloch* having obtained a positive Wassermann reaction in the cerebro-spinal fluid of three men the subjects of general paralysis, in all of whom a saturnine association was more than probable, are of the opinion that saturnism can only be a coincidence in the development of general paralysis. They maintain that they have never obtained a positive reaction in persons suffering from acute or chronic plumbism in whom there was no history of syphilis or the possibility of it. In my infirmary lead patients I only obtained a positive reaction where I had

* "Saturnisme et Paralysie Générale," *Revue Neurol.*, 2e sémaine, p. 118. 1910.

reason to believe that in addition to plumbism there was a specific taint. Its absence in a male patient whom I had regarded as a pseudo-general paralytic, with the sequel of plumbism, supported the attitude I had taken up in the matter. With the view of ascertaining in what percentage of lead workers a positive Wassermann reaction might be obtained in men still following their occupation, I asked permission of Dr. Irvine to allow me to make tests upon some of the workers in the factory of which he is the medical adviser. With the assistance of Dr. H. J. Slade, Bacteriologist to the Royal Victoria Infirmary, Newcastle, we took the blood of different sets of work-people in different weeks. The following are the results: (*a*) Of blood of 11 men examined 8 gave a positive reaction; (*b*) of blood of 11 men examined 4 gave a positive reaction. Whatever view we take of the Wassermann reaction the fact remains that plumbism gives rise to a series of nervous phenomena closely resembling those observed in general paralysis. The two conditions, however, are quite distinct. It is not always the case of syphilitic general paralysis having developed in a person who is at the same time the subject of plumbism, but of a malady inexplicably the outcome of saturnism exerting its final influence upon the central nervous system.

General Pathological Review of the Subject.

The symptoms of lead poisoning, whether caused by working in lead, inhaling dust, or drinking water contaminated by lead, are due to (1) lead compounds circulating in the blood; (2) the formation and retention of toxic products within the system causing deranged function of the excretory organs; and (3) to structural changes of internal organs consequent upon the action of lead or of the toxic bodies produced as consequences of it. All physicians are agreed that plumbism is more likely to be the result of the frequently repeated entrance of small quantities of lead into the system than of one or two large doses. Where large doses of lead are given by the mouth—*e.g.*, 15 or 20 grains of acetate of lead—only a minute quantity of this is likely to be absorbed. The bulk of it is thrown out in the fæces, but in the case of a lead worker who is breathing or swallowing dust, minute quantities only reach the internal economy at a time. As in the latter instance exposure to the metal continues for months or years, considerable quantities of lead can thus be absorbed over the extended period. Ordinarily the elimination of lead keeps pace with absorption, and so long as the workman is having good meals, digesting his food well, and is giving attention to details of personal hygiene, health, in spite of the harmful nature of the work in a lead factory, may be well maintained; but if there is any idiosyncrasy or personal susceptibility to the metal, if there are poverty and semi-starvation, excessive indulgence in alcohol, or the supervention of illness, elimination of lead by the fæces becomes checked, and health may become undermined. It is therefore the frequently repeated minor injuries inflicted upon the cells of the body and upon the internal organs by lead which do harm. Lead may be stored up in the body for years, as in the case of a bullet which becomes encysted, or it may have been deposited as a comparatively insoluble albuminate, and given rise to no trouble until metabolism becomes deranged, when the inert lead becomes dissolved and is reabsorbed into the blood. So far as workers in lead are concerned it is difficult to say what length of time is required of persons exposed to lead for symptoms of plumbism to develop. Employers in the United States are of the opinion that the best way to protect workmen is to keep them in the factory only for a short period—a few weeks or a few months at most—employed in dangerous processes. British experience, on the other hand, shows that it is the casual workers in the lead factories who suffer most. Where men follow the employment regularly owners of works are more likely to introduce improvements than when the labour is largely casual. In visiting a large lead works on the Continent some months ago, although several of the men looked pale and somewhat ill, I was struck by the register showing a remarkable freedom on the part of the men from sickness. On drawing the manager's attention to the circumstance, he attributed the freedom from illness on the part of the men to the fact that the firm did not allow the men to stay long enough for them to become ill. The workmen were kept circulating. In Great Britain the workmen stay longer with white lead manufacturers than they do in many parts of the Continent and the United States.

Since in lead workers plumbism is the result of the inhalation or swallowing of plumbiferous dust, the date at which symptoms of poisoning develop will be influenced by the amount of dust in the atmosphere, by ventilation, previous state of health of the work-people, and their susceptibility. Tancquerel mentions the case of a man who developed paralysis after having worked in a factory only one week. One of my patients developed plumbism after eight days' work in a small room where he was making electric accumulators for a colliery. Dr. Alice Hamilton, of

Chicago, found in hospital a white lead worker who had been admitted for colic and neuritis after having worked only three days. Her experience of other cases is equally interesting. Of 120 patients whom she examined, 8 had become ill in less than two weeks after taking up the work, 36 in less than a month, and 89 in less than a year. Of 64 bath-enamellers, 1 became ill in less than a fortnight, 2 in less than one month, and 19 in less than one year, while 42 had worked more than one year. A house-painter working indoors and employed in sandpapering suffered from convulsions at the end of nine weeks; for three days he lay in a state of coma, recovered slowly and returned to work at the end of three months. In *Vorwarts*, 1897, the following data afford information as to the periods in which symptoms of lead poisoning showed themselves in nine men who were working in a small electrical accumulator factory:

1	man became ill	with colic	after	1·5	weeks.
1	"	"	"	2·5	"
2	"	"	"	3·5	"
1	"	"	"	4·5	"
1	"	"	"	5·5	"
1	"	"	"	6·0	"
2	"	"	"	7·5	"

What Amounts of Lead are Harmful?

Several workers in the field of industrial hygiene have attempted to throw light upon this subject. From a worker's point of view it would be of assistance to us if we knew something definite in regard to this, but the problem is surrounded with difficulties. Experiment has therefore had to be resorted to, most of the lead being given in solution in drinking-water. A little while ago the water of Berlin was found to contain 0·3 milligramme of lead per litre. This amount of lead was not productive of harm. Dr. Angus Smith and Professor Rubner tell us that 0·36 milligramme of lead per litre of water is the limit of safety. After standing for twelve hours, if water has taken up from lead which has been immersed in it 1 milligramme of the metal per litre, this amount is believed to be dangerous. Intoxication by lead has been caused by people drinking water which contained 1·6 milligrammes of lead per litre, but symptoms have also followed when the water contained 0·5 milligramme. Of 38 persons living at Castle Clermont, 13 fell ill after having used for nine months water which contained 0·2 to 1·5 milligrammes of lead. Teleky gives it as his opinion that if 1 milligramme or a little more of lead is taken daily for several months it will cause plumbism, and that a daily dose of 10 milligrammes will lead to serious intoxication after a few weeks. In the instances just recorded it ought to be remembered that the lead was in solution, and was passed directly into the alimentary canal. The conditions, therefore, do not exactly compare with inhalation of lead dust in a factory. Here we need hardly again raise the question of whether lead dust is absorbed directly from the respiratory passages or from the alimentary canal, but dealing with the latter as probably the more likely channel, it may be said that 100 cubic centimetres of 0·1 normal hydrochloric acid will dissolve 10 milligrammes of lead in a comparatively short space of time; during the same period 28 milligrammes of sulphate of lead will be dissolved, 28 of sulphide, and 7·4 of chromate. Clearly, therefore, small quantities of lead can always be readily dissolved in, and be also readily absorbed from, the stomach. It is the minute quantities of lead which do harm, for larger quantities would be less likely to be dissolved and absorbed.

Without regarding these results as in any way conclusive, it may be stated that the amount of fume given off into the atmosphere by molten lead has been estimated. Lead melts at 325° C., and vaporizes at about 650° C., if there is no slag on the surface to prevent the escape of the oxide.

Tischler found 2·5 to 9 milligrammes of the metal in 100 litres of air removed from immediately above the reservoir of molten lead attached to a stereotyping machine, and Kaup found in the air of the drying-ovens in a white lead factory taken at the level of the lips of the workmen, 0·134 milligramme of lead. Müller found in the air of a lead smelting works 236·8 milligrammes of lead in 100 litres of atmospheric air at the place where the men were working, and that after a hood had been erected the air contained only 0·29 to 0·56 milligramme of lead per 100 litres. If, as Teleky says, we consider that 4·5 cubic metres of air are taken into our lungs in ten hours—that is, during an average working day—the amounts of lead inhaled may be anything between 6 and 25·2 milligrammes. Kaup found in 100 litres of air in a white lead factory 0·122 to 0·271 milligramme of lead; this, he believed, would give 5·49 to 12·2 as the amounts of lead in milligrammes which might be inhaled by workmen daily. In paint mixing and dry colour grinding, there may be 0·178 to 0·25 milligramme of lead per 100 litres of air. Men exposed to such quantities of lead can hardly escape becoming lead-poisoned. When we add to the possibility of harm arising from breathing a dusty atmosphere that arising during eating from the soiled hands of the workmen, the danger becomes greater, for Müller, at the close of a working day, obtained from the hands of men employed in lead smelting works 0·7 milligramme, 11·28 milligrammes, and even as much as 643 milligrammes of lead. Such quantities of lead adhering to the hands of workmen show the necessity there is for workmen to wash carefully before taking food.

Additional information bearing upon the question of the amount of lead required to cause plumbism has also been obtained from experiments upon animals. Walter Straub,* of Freiburg, in co-operation with Erlenmeyer, made experiments with cats and rabbits. Straub injected freshly precipitated lead carbonate under the skin of the back of a rabbit on September 1, 1908. On November 7 the animal remained well, but after this date there gradually developed paralysis of the fore-limbs, and subsequently spastic paralysis of the hind-limbs, especially of the abductor muscles; the hair fell off, and the skin atrophied, but the animal retained its weight. It died on January 3, 1909, 124 days after having received the injection of lead. At the autopsy Straub found at the site of the injection a considerable quantity of unabsorbed lead. Cats similarly treated died in seven to twelve weeks after the injection from bulbar

* *Muenchener Medizin, Wochenschrift*, January 6, 1914, p. 5.

paralysis, preceded by loss of weight. Professor Ascher made microscopical sections of the organs of the cats poisoned by Straub and Erlenmeyer. He found pathological changes in the spinal cord. There was an intense cellular infiltration of Goll's and Burdach's columns. The blood of the animals was examined by Professor H. Schridde, but not in the blood of one of them did he find the basophile red corpuscles which are regarded by some physicians as pathognomonic of plumbism. In the eight to ten weeks during which the animals lived after the injection, Straub found that 0·1 to 0·2 gramme of lead had been absorbed, admittedly a minute quantity to be capable of causing such an amount of harm. Straub observed that all through the experiment lead was being thrown out of the body by the urine. His opinion is that at any particular period traces only of lead are retained in the organism, that there is never any large accumulation of lead, and that, as already mentioned, it is the heaping-up of the minute injuries inflicted upon the body by such delicate quantities which are the cause of plumbism. From the site at which the injection had been made, a current of measurable quantity of lead keeps passing through the animal. It would be important to know the actual amount of lead injected into an animal, the amount of lead eliminated daily in the urine during the period of the experiment, also on cremating the animal after death the amount which had been left in the body. This would give an approximate idea of the amount of lead capable of giving rise to plumbism. Erlenmeyer attempted to do this and he concluded that 99 per cent. of the lead lost from the deposit at the site of injection in the back of the animal could be accounted for by having been eliminated in the urine, and what remained in the ash of the body after death. Erlenmeyer found that plumbism was fatal if 0·06 gramme of lead per kilo of body-weight passed daily for sixty days through the animal. He gives as the formula for fatal lead poisoning in the cat per kilo of animal:

$$\frac{\text{lead carbonate}}{60 \text{ days}} = 0{\cdot}00004 \text{ gramme hours,}$$

that is, $\frac{4}{1000000}$ part of a gramme of lead must pass per hour through each 1 kilo weight of animal in order to be fatal. In other words a cat dies from bulbar lead paralysis if an intensity of lead current equal to 0·00004 gramme of lead flows through each kilo of its body-weight per hour for sixty days. An effort has thus been made to determine the amount of lead capable of producing in animals organic disease of the central nervous system by means of lead. The above can only be regarded as an approach to a solution of an important problem. Bulbar paralysis is in man a rare form of industrial plumbism, but the fact remains that there are forms of paralysis and other signs of degeneration of the central nervous system in man due to chronic lead poisoning which have hitherto escaped recognition, on account of their atypical nature, and the absence of the usual accompaniments of plumbism.

Lead absorbed into the system cannot circulate in the blood without inflicting injury upon such of the eliminating organs as the kidneys and liver. If it leaves the blood for the tissues it passes into stable combination with their proteids. In the tissues it may remain in the comparatively insoluble form of albuminate. Under circumstances which we can neither foresee nor explain, but of which the influence of potassium iodide is an illustration, the lead albuminate stored in the tissues may become redissolved, and on being reabsorbed into the blood may again induce symptoms of plumbism. In the intestine of patients who have died from lead poisoning, and equally in animals the subjects of experimental plumbism, bluish-black patches are occasionally observed in the mucous membrane due to a deposit of lead sulphide. As the patients in whom I have seen these patches had been the subjects of obstinate constipation, it seemed as if these patches were situated at those parts of the alimentary canal where the fæces had lain longest in contact with the intestinal mucous membrane. Since it is primarily to the liver that lead absorbed by the intestinal veinules is carried, it is in this organ that we look for structural alterations; but although after death the largest amounts of lead are usually found in the liver, the changes of structure in that organ are as a rule less pronounced than they are in the kidneys. On microscopical examination the liver cells may be found atrophied, they may have undergone fatty degeneration, or there may be an increase of the interstitial tissue, such as to recall a mild form of cirrhosis of the liver. The cirrhosis may be intercellular or interlobular. In a female who died from plumbism, the result of drinking water contaminated by lead, there was marked fatty infiltration as well as fatty degeneration of the liver, while in the same organ of an infant who died two weeks after birth, whose parents were both lead workers, there was atrophy of the liver cells with marked increase of the interlobular tissue.

To the rôle of the liver in saturnine poisoning fresh interest is attached through the experiments of MM. A. Roncato* and P. D. Siccardi, who submitted healthy dogs to injections of neutral acetate of lead. On comparing, microscopically,

* *Archivio di Fisiologia*, 1913.

sections of the liver of these dogs with those of healthy animals, they found numerous black granules in the cells of Kupfer which are not present in the same cells in healthy dogs. Roncato and Siccardi are of the opinion that the black granules are essentially metallic lead, that hepatic cells are capable of reducing salts of lead, and that they have the power of fixing the metal. Thus may be explained some of the peculiarities of plumbism. Lead poisoning not only develops slowly, but long after a man or woman has retired from a lead works and has ceased to be absorbing the poison, plumbism may yet develop. Such attacks of plumbism, always with difficulty explained, may be due to the fact that under certain conditions the hepatic cells had temporarily lost the power of retaining the lead which was lying reduced in the interior of the cells.

Of all the internal organs the kidneys are perhaps those in which structural changes are most marked. Because interstitial nephritis or contracted kidney is the most common pathological event in chronic plumbism, this has come to be regarded as the typical renal lesion of lead poisoning. It is undoubtedly the lesion of chronic lead poisoning; it is found in persons who have worked in lead for years. As an accompaniment there is frequently widespread thickening of the small arteries. Long before the kidney, however, has undergone structural change, its function may have been deranged, for albuminuria may be met with in the early stages of plumbism. Albuminuria may occur during an attack of colic; it may disappear under treatment and return again during another attack of colic. I have seen albuminuria develop almost immediately in lead workers after the administration of potassium iodide, and just as rapidly disappear on cessation of the medicine. Where a lead worker dies from acute plumbism after having been employed for only a few weeks or months in a factory, the lesion in the kidney is not interstitial but tubal. The renal epithelial cells are swollen; they are the seat of cloudy swelling or of fatty granular degeneration. The cells break down and fill the tubules with débris. Inside the glomeruli there may be evidence of cellular proliferation, whilst leucocytes may be gathered around the afferent vessels.

In the early stages of lead intoxication, therefore, as might be expected from the fact that the kidneys are important organs of elimination of lead, the renal epithelia and glomeruli suffer most, a circumstance which explains some of the nervous accidents which occur in the early stages of the malady, and which are the combined result of auto-toxis and plumbism. Bouchard drew attention to the fact that if the urine of a lead worker who is, comparatively speaking, in good health is injected into an animal, it seems to possess highly toxic properties, for the animals become convulsed; but if the urine removed from the bladder of a lead worker who is suffering from convulsions is similarly injected, it is found to have lost most of its toxic power owing to the poison or poisons being retained within the body and blood of the patient. In other words, the convulsive seizure would be a sign that lead was not being eliminated.

Only once have I found hæmatoporphyrin present in the urine in lead poisoning. For its detection the spectroscope must be resorted to. Steinberg holds that hæmatoporphyrinuria is due to small hæmorrhages in the intestine.

Salivary glands eliminate lead. In the saliva of some of my patients to whom I had administered pilocarpin, Professor Bedson found 3 parts of lead per million. In the mucus which escaped from the nostrils of a rabbit undergoing the double electrical bath treatment Clague found lead.

Judging from the conditions observed in chronic plumbism lead exercises little effect upon the heart unless through the intervention of the bloodvessels.

It is hardly to be expected that symptoms of lead poisoning will develop until absorption of the metal has for a period exceeded its elimination, and even then it is not uncommon for some persons to go on working in a factory apparently in good health until something happens such as illness, or excessive drinking is indulged in, whereby the functional activity of the internal organs becomes temporarily deranged.

Lead and Female Life.

Apart from individual and family idiosyncrasy there is a sexual predisposition to lead. On the whole, females, particularly young females, suffer more severely from plumbism than males. This is largely the result of the disturbance of their menstrual life. In some persons amenorrhœa follows exposure to lead, in others there is excessive menstruation. The severe headache experienced by females exposed to lead may therefore be a direct consequence of the action of lead, or indirectly the result of menstrual derangement.

Lead and Motherhood.

Since 1898, or thereabouts, the year in which, in consequence of Home Office regulations, females ceased to work in the dangerous processes of lead manufacture, but to whom was still permitted such work as the making up of blue beds, and the washing of the men's overalls, bath-towels, etc., the number of cases of plumbism in females has considerably decreased. It was the large number of cases of plumbism, many of them rapidly fatal in young women, which led to the abolition of female labour in dangerous processes. In potteries women are still allowed to work where glaze containing lead in small quantities is used. Taking the pottery statistics for 1898, there were 3,123 men employed in lead processes in North Staffordshire. Of these 152, or 4·9 per cent., suffered from plumbism, while of 1,580 women similarly employed, 196, or 12·4 per cent., suffered. Of 12 deaths from plumbism 11 occurred in females. In the Annual Report of the Chief Inspector of Factories, 1912, the cases of reported lead poisoning per 1,000 persons employed are for males 11, and for females 19; but when some of the occupations are taken separately—*e.g.*, that of dippers' assistants, in which both males and females are together employed—the cases of lead poisoning are for males 8, and for females 19, and for ware cleaners, males 11, and females 35. Previous to the exclusion of females from the dangerous processes in lead works there occurred, over a period of a few years, in Newcastle-upon-Tyne, 23 deaths from plumbism, of which 22 were of females.

My contention is that it is largely owing to the power of lead to inflict harm upon the reproductive organs of women that the female sex is so liable to be adversely influenced by the metal. In consequence of its ecbolic action it is difficult for pregnant females to proceed to term if they remain at work in the factory. They are almost certain to miscarry and to have either a stillborn infant, or the child, if it is born alive, dies in convulsions a few hours or days after birth. The only means by which I succeeded in getting lead workers who had miscarried six or seven times in succession, when again pregnant, to reach term was by keeping them off work. The following cases bear upon these points. Some of them are now old infirmary patients of many years ago.

Mrs. K., aged thirty-four, had four children before going into the lead works, and two children in the early part of her lead career afterwards. Continuing at her employment she had six miscarriages in succession. After the last miscarriage she was admitted into the infirmary under my care, suffering from paralysis of arms and legs due to lead. She made a slow but complete recovery. Acting upon my advice, she did not return to the factory. In her next pregnancy she went to term and bore a living child.

Mrs. A., aged forty, was a lead worker for several years. She has had eight children, all of whom died in convulsions.

Mrs. C., aged twenty-four, until a little while ago lived on a farm, where she gave birth to a healthy infant. Four months previously to seeing me she had taken up work in a white lead factory. Within three months she miscarried.

Mrs. E. A., aged forty-six, had three children before going into a white lead factory. These children are still alive. After she became a lead worker she had nine children, all of whom died before the age of four months. She gave up work in the factory, and in due course gave birth to a healthy child, who at the time of writing is still alive.

Mrs. E. W., aged fifty-nine, worked in a lead factory all her married life. She had ten children, nine of whom died under three years of age. The surviving child is undersized, ill-developed phsyically, and is weak mentally.

Mrs. W., aged sixty-six, worked twenty-two years in a white lead factory. She suffered from convulsions. She had six miscarriages and ten children born alive. Five of the children died in the early months of infancy in convulsions. One of the remaining five, a daughter, Mrs. L., aged thirty-seven, was also for several years a lead worker. She had on one occasion before her marriage severe colic. Mrs. L. has had one still-born child, one miscarriage, and four children, all of whom are alive and healthy.

Of thirty-six women, formerly white lead workers, who have come under my notice, the following are the results of their pregnancies—294 in all:

51 miscarriages,
16 stillbirths,
104 infants died shortly after birth,
17 infants died within a few years of birth—

a total of 188 early fatal results, and of 106 living children.

An interesting point in regard to maternity and plumbism is that, while an expectant mother does not show any sign of plumbism, and is apparently not suffering from lead poisoning, she transmits to her babe such a legacy of lead that the infant is born dead, or dies shortly after birth. The same thing is observed in animals. In the case of one of my laboratory rabbits who had received lead during pregnancy, two of her litter of nine died within two days after birth, and from the body of each of these animals Mr. T. M. Clague, analytical chemist, recovered $\frac{1}{16}$ grain of lead. Yet the mother rabbit was quite well and did not suffer from lead poisoning at all. When women worked in the white lead factories of Newcastle, they maintained that child-bearing relieved them of the risks of becoming lead-poisoned, for they passed on the lead to the fœtus *in utero*. The infant died, but the mother's body had parted with lead. The placenta allows of soluble lead compounds to osmose from the maternal into the fœtal blood, to be retained in the body of the fœtus, to induce structural changes therein, and to destroy life.

I have given in detail some of my experience of lead poisoning and maternity. It is to M. Paul, a French physician, we are indebted for much that we know of this subject. He tells us that of fifteen pregnancies of four women who had worked in a type-foundry, ten ended in abortion, two in premature labour, one in stillbirth, and one child died within twenty-four hours of its birth. In another series five women had given birth to nine children before working in lead without one abortion. After exposure to lead there was a total of thirty-six pregnancies: of these twenty-six ended in abortion, one in premature labour, two in stillbirths, five children died, four of them in the first year of life.

Not only has working in lead a disastrous effect upon pregnancy, it would almost seem as if pregnancy itself predisposed to plumbism. Teleky relates the following: F. T., aged seventeen years, a polisher, worked in a bottle-stop factory from March, 1907, to July, 1907, without being ill. Later on, becoming pregnant, she continued to follow her occupation from March 10, 1908, until May 13, 1908. From May 13 to June 13, 1908, she suffered from plumbism. On June 23 her child was born prematurely, and lived for only seven weeks. She made a good recovery, and returned to the factory, where she worked from the middle of August, 1908, until October 9, 1908, when she again broke down in health from plumbism. F. T. remained off work until December 28, 1908, when she returned to the factory and followed her occupation until February 10, 1909, when she again suffered from lead poisoning, had a marked blue line on the gums, was extremely anæmic, and altogether seemed seriously ill. In the latter half of the month of March—that is, fully one month after having left the factory—she developed paralysis of both hands and slight paralysis of the feet. The paralysis of the feet improved, but in 1910 the hands were still helpless. It was not until 1911 that the hands had improved.

The above is the case of a young woman seventeen years of age, who had worked in a lead process for four months with good health. In the following year, when *enceinte*, she works for two months, when she has lead poisoning. The infant born alive dies within seven weeks. Meanwhile, the mother returns to work as a polisher, and follows her employment for two months, when she is obliged to give up work for ten weeks on account of lead intoxication, from which she recovers sufficiently to return to work for six weeks, when she breaks down in health and develops a few weeks afterwards a form of paralysis from which she had not recovered a year afterwards. In this particular instance Teleky was of the opinion that pregnancy had exaggerated the susceptibility to plumbism.

In these remarks I have dealt with the harmful influence of lead upon the product of conception where the mother alone has been exposed to lead. As illustrating the injurious effects upon the progeny when the father is working in lead, I fall back upon information supplied by Dr. Carozzi, of Milan. Of 455 pregnancies of women whose husbands were type-smelters, 277 ended in living births, 117 in stillbirths, and in 67 instances in miscarriages. Among women working at the lead mines in Sardinia, most of them being employed in the smelting-shop, 1,483 pregnancies occurred; 829 children were born alive, there were 326 stillbirths, and 326 miscarriages; whilst 199 pregnant wives of men working at the mines bore 36 living children, had 108 stillbirths, and 55 miscarriages. Lead clearly exercises, therefore, a deleterious influence upon the seminal fluid of the male. Professor Lewin, of Berlin, tells us that of seven women married to men working in lead all of them gave a history of miscarriages. Of 32 pregnancies only 2 living children were born. In colour works in which lead was used, Carozzi found with saturnine fathers 48·4 per cent. of living children, 37·2 per cent. of still-births, and 14·4 per cent. of miscarriages, or a total death and miscarriage rate of 51·6 per cent.; while Frogia found the numbers to be respectively 18, 54·4, and 27·6 per cent., or a total of 82 per cent. death and miscarriage rate where the fathers worked in lead, while as regards saturnine mothers the infant death and miscarriage rate was 44·1 per cent.

Contrary to my own experience and that of many other physicians, Carozzi and Frogia are of the opinion that the influence upon progeny of a father who has been employed in lead is even greater than that of an expectant mother who had been similarly exposed. In opposition to this, Rennet states that where the mother alone is exposed to lead the conception is damaged in 92 per cent., and in paternal saturnism the damage is 63 per cent.

Where both parents work in lead the effect upon offspring is much greater than where only one of them is employed. Lead is a racial poison; it destroys the fœtus *in utero* directly, or it cuts short its stay in the womb by its action upon uterine muscular fibre.

Blood-Pressure Experiments.

Before discussing the question of lead poisoning and blood pressure, let us see what happens when lead is directly introduced into the blood stream. With the view of ascertaining upon which organ or organs of the body lead primarily acts when administered intravenously, I carried out a series of experiments, in which I was ably assisted by my colleague, Professor R. A. Bolam, to whom I gratefully acknowledge my indebtedness.

In pharmacological textbooks lead is spoken of as a specialized poison for most of the tissues and organs of the body, and is said to be a general poison to protoplasm. Its effects are observed more upon the highly developed tissues, such as muscle and nerve, than upon blood, although we know that in time the blood becomes affected also. Lead is said to act upon muscle fibre and to produce fatigue. It certainly acts upon unstriped muscle fibre, as illustrated by forcible emptying of the pregnant uterus and its constricting effect upon the small arteries. Riegel found the blood pressure heightened in lead colic, but in many of my own cases the pulse was small and feeble, and the heart's beat so weak that the sounds were practically inaudible.

With the view, therefore, of clearing up some doubtful points, Professor Bolam and I undertook the following experiments,* which consisted in the intravenous injection of varying quantities of solutions of nitrate of lead into dogs anæsthetized by chloroform or ether. When 5 cubic centimetres of distilled water were injected into the vein of a dog, no effect was produced on the arterial pressure. The injection of 5 cubic centimetres of a 1 per cent. solution of lead nitrate was followed shortly afterwards by a slight fall of blood pressure. Five cubic centimetres of a 2 per cent. solution were also followed by a slight fall, which in each instance was quickly recovered from. After an injection of 10 cubic centimetres of a 10 per cent. solution and recovery from a pronounced fall of arterial pressure, a second injection of the same quantity and strength of nitrate of lead was succeeded by a rapid declension of pressure and stoppage of the beat of the heart. Respiration continued. After an interval of from three to four minutes the heart recovered itself; the beats returned feebly at first, and becoming stronger, they gradually reached the normal. In consequence of a further injection of 5 cubic centimetres of a 10 per cent. solution, there

* "Some Unusual Features of Lead Poisoning." By Thomas Oliver, M.D. A lecture delivered at the Polyclinic in London, May 19, 1909. *The Hospital*, May 29 and June 5, 1909.

occurred a fresh decline in the arterial pressure of brief duration, but on injecting a double quantity of a double strength of lead nitrate solution the blood pressure rapidly fell, and to an extreme degree, although respiration continued. Several struggling beats of the heart occurred, and the respiration became interrupted. By degrees the heart stopped beating; respiration also ceased. At the autopsy twenty-four hours afterwards the urine was found free from albumin, but it contained a reducing substance which acted upon Fehling's solution. The wall of the heart was flabby, especially that of the right ventricle. The right ventricle contained a small quantity of dark-coloured blood. Lungs were healthy, the abdominal veins were full and tense, kidneys appeared to be congested, the liver was dark but healthy, and the brain was slightly congested on the surface, although on section pale internally.

By a male dog, into whose veins 5 cubic centimetres of a 5 per cent. solution of lead nitrate were slowly injected, and whose blood pressure had been gradually restored after the primary fall, amyl nitrite was inhaled, the result being a fresh fall of arterial pressure. On recovery of this the effect of a renewed injection of lead nitrate solution was a rapid fall of blood pressure with a rise of the respiratory curve, possibly the result of stimulation of the respiratory centre through want of blood. The beat of the heart and the respiratory movements ceased, but spontaneous attempts at respiration were renewed at intervals of two to four minutes, after which they ceased, the beat of the heart never having been re-established. At the autopsy nothing specially was found, except that the heart was filled with fluid blood and the abdominal veins were turgid.

Whether the animal made use of in these experiments was a rabbit or a dog, the effects of the intravenous injection of a solution of lead nitrate were invariably the same—viz., a general fall of blood pressure. This occurred equally in the splanchnic area as in the general systemic vessels. In the splanchnic area it was gradual, but yet on the whole fairly rapid. The heart would stop, but the beat might be recovered.

The effect of lead salts carried directly into the blood stream is upon the heart and vasomotor centre; the fall and subsequent rise of arterial pressure occur simultaneously in the systemic and splanchnic vessels. Respiration is not directly affected by lead; it is only indirectly affected through the falling blood pressure. One of the noticeable effects of the continuation of respiration is the re-establishment of the beats of the heart.

In reviewing the results of the injection of lead into the venous system, it cannot be said that there is any striking uniformity in regard to the amount of lead required to cause death. It is known that some men and women are less liable to be affected by lead than others. There is a personal idiosyncrasy. In animals experimented upon no difference as to susceptibility was noticed between males and females. The previous injection of atropine had not the slightest influence in altering the effect of lead upon the heart or of preventing the fall of arterial pressure.

The accompanying tracings illustrate the effects of lead upon the heart and circulation.

Blood Pressure and Working in Lead.

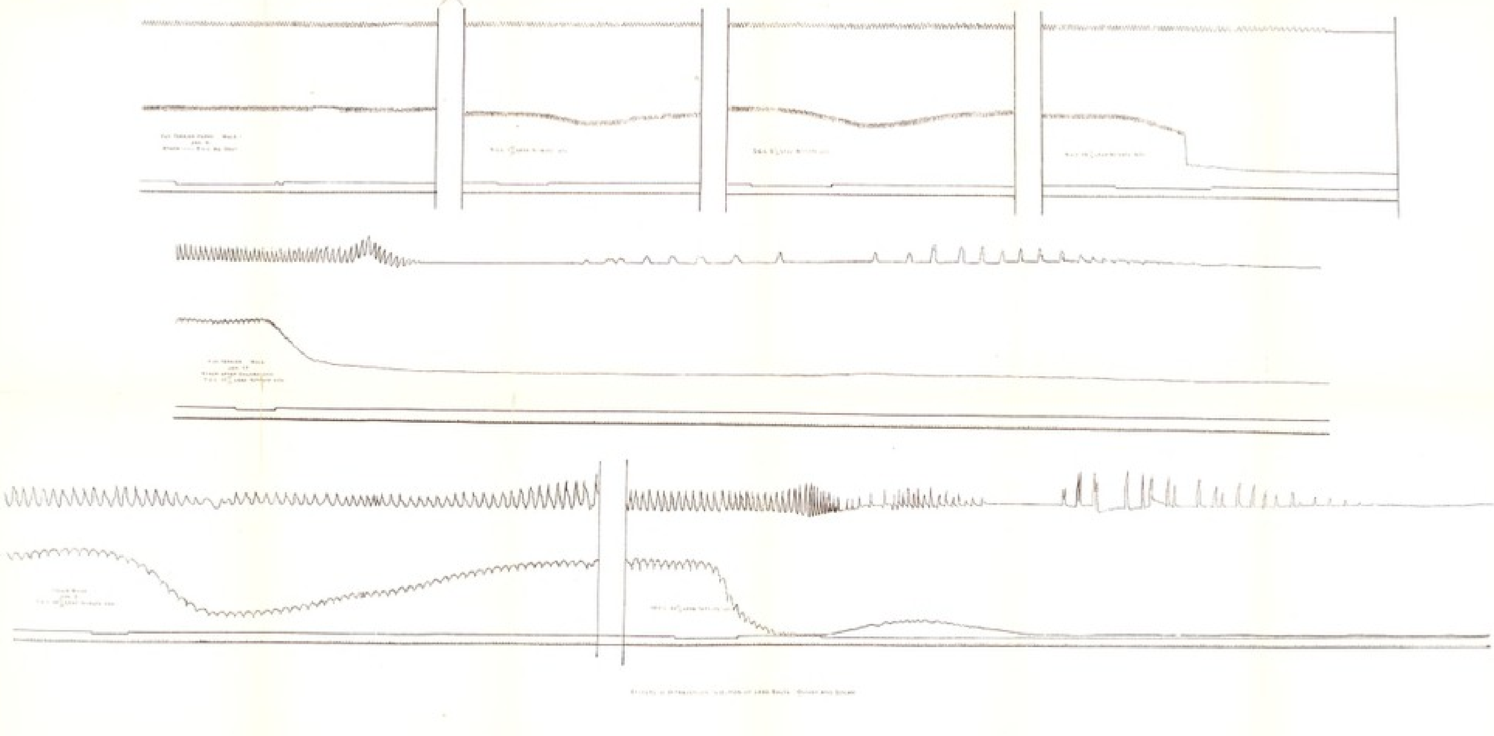
During attacks of lead colic Riegel found the blood pressure heightened, a circumstance to which he was disposed to attribute the abdominal pain, believing that the arteries of the splanchnic area were constricted. Some of the cerebral symptoms, too, he thought, might be explained by a similar state of the vessels of the brain followed by localized œdema through increased permeability of the capillary walls. Rambousek differentiates between the symptoms which arise in the early stages of plumbism, and those met with in the chronic forms of the malady in which structural changes have already been established

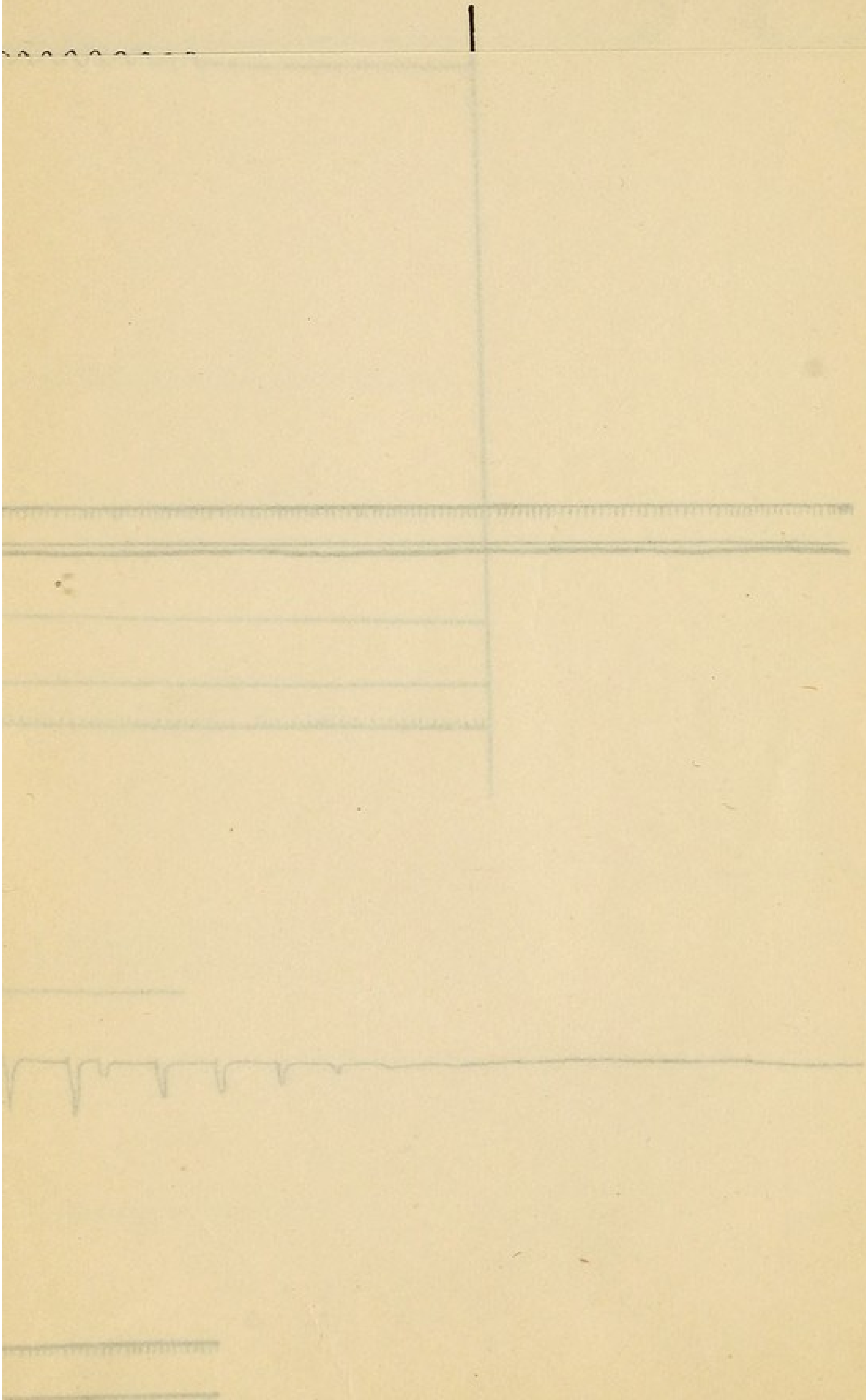
During the later stages of colic the radial pulses are frequently unequal. There is an opinion that work in lead tends to raise the arterial pressure. Dr. Edgar Collis found the average blood pressure of 141 lead-smelters to be 148·2 millimetres Hg, and of 38 white lead workers 156. In one of the white lead factories in Newcastle-upon-Tyne, all the men who apply for work are submitted to a blood-pressure test. A sphygmogram is taken. Every workman with an arterial tension above 140 millimetres Hg is rejected. On examining the sphygmographic tracings of eighty-four men taken when they commenced work and comparing them with the tracings taken after a year's service in the factory, considerable variations are observed, but there is no absolute uniformity. In one man who had a blood pressure of 126 when he commenced work, the pressure rose a few months afterwards to 134, and then gradually fell to 112. I have not observed a continued rise of blood pressure in the early part of the career of lead workers, nor is there any pronounced persistency. A workman whose blood pressure was 138 millimetres Hg, and next week 130, may in the following week have a still lower pressure, or it may be higher. The average blood pressure of the eighty-four male lead workers referred to above was 122·3; the highest recorded was 138, and the lowest 100. One of the men had a blood pressure of 169, but his urine contained albumin, and he seemed to be the subject of granular kidney, a circumstance which in him and two other workmen raised the question whether the high arterial tension was the consequence of the action of lead *qua* lead upon the bloodvessels, or of the poisonous products formed in the body as the result of the action of lead upon such of the internal organs as the liver and kidneys.

In the series of blood-pressure experiments made by Professor Bolam and myself, and to which attention has been drawn, death came, as can be seen from the charts, through a fall of blood pressure, owing to the effect of lead upon the heart. These experiments show how minute quantities of lead can adversely affect the heart and circulation. The average blood pressure of another series of men working in white lead in Newcastle-upon-Tyne was 131·4, and the highest 180. It seems to me that during the early years of employment in a lead factory the work does not affect to any marked degree the blood pressure, but there is hardly any doubt that as time goes on and the function of the eliminating organs is interfered with, the blood pressure rises, also that structural changes are induced in the arteries, for only by this means can be explained the large number of deaths from cerebral hæmorrhage in persons who have worked in lead. The duration of the employment and of the particular kind of work the men follow in the factory, their home life and habits, must materially influence this question of blood pressure.

Chemical Examination of the Urine and of the Organs of the Body for Lead.

In testing for lead in urine Professor Bedson, Armstrong College, Newcastle-upon-Tyne, makes use of the following method: 50 cubic centimetres of urine are placed in a shallow porcelain basin and evaporated practically to dryness on a water-bath; it is carbonized in a muffle furnace; the residue is moistened with strong nitric acid, and ignited gently. The residue is perfectly white. This is moistened with strong hydrochloric acid and evaporated to dryness. It is ignited gently on a muffle and cooled; a few drops of hydrochloric acid are added, and then water; it is allowed to stand for a few minutes, after which it is poured into a Nessler glass. The solution is made just alkaline with a few drops of ammonia, then slightly acid with a few drops of hydrochloric acid. If necessary it is filtered, and the amount made up to 50 cubic centimetres. To this are added 2 cubic





centimetres of freshly prepared sulphuretted hydrogen. A dark coloration indicates lead (all other metals being known to be absent). The estimation of the amount of lead is effected by a comparison of the coloration produced under like conditions with a standard lead solution.

Several methods of detecting lead in urine and organic compounds are described in the textbooks —also of detecting lead in the organs after death. As the methods are complex and require considerable knowledge of analytical chemistry, I prefer to have all these examinations carried out for me by competent chemists, and in view of the questions which might be raised in cases connected with the Workmen's Compensation Act, I would advise medical practitioners to refer such examinations to analytical chemists whose skill and verity are beyond question.

Anomalous Symptoms due to Drinking Water Contaminated by Lead.

I have not the slightest doubt that there are many cases of illness attended by obscure nervous symptoms of which no explanation can be given, and which are illustrations of atypical plumbism. Patients thus suffering are seen and treated by medical men without the true nature of their malady being recognized. This is likely to occur when there is no history of exposure to lead offered by the patient or elucidated by the physician. Where the teeth are kept clean by brushing, and there is no blue line on the gums, one important sign, at least, of plumbism is wanting; and where colic has never been so severe or recurrent as to have impressed itself upon a patient, another recognized symptom of plumbism is absent. An increase in the number of miscarriages or of stillbirths in a town or district should cause medical men to suspect lead either in the drinking-water or in drugs taken surreptitiously. If neuralgia be set aside, severe headache in the absence of signs of cerebral tumour, organic disease of the brain, and the possibility of structural defects of the eyes may, if attended by anæmia or cachexia, be reasonably regarded as toxæmic. The phenomena to which I want specially to draw attention as suggesting plumbism are a gradual enfeeblement of the physical and mental powers with loss of weight, impaired locomotion, also a train of nervous symptoms, of which sleeplessness, intense depression of spirits, forgetfulness, inability to apply oneself to mental work, with at times symptoms simulating hysteria or general paralysis are the most prominent. These symptoms in the absence of a blue line on the gums or of a history of colic are frequently due to plumbism, as shown by a chemical examination of the urine. Owning such a cause, the symptoms are exhibited by persons under unexpected circumstances, both as regards place and social position, that it is no surprise medical men are thrown off their guard. In many of the cases there is no basophilia, but lead is found in the urine during life, and in the internal organs after death. In many of the cases the cause of the illness has been the domestic use of drinking-water possessing high plumbo-solvent powers. Given an affected area, the consequences may be far-reaching, as the sequel shows. Some months ago I was asked by a medical friend to see in consultation with him a series of cases which, notwithstanding their atypical character, were undoubtedly plumbism. One of the patients, a young married woman, had recently been confined. During the course of her convalescence, and when, from an obstetrical point of view, there was nothing to cause acute abdominal pain, she became the subject of severe headache. Her infant, although at the breast, was losing flesh instead of gaining it, was constantly crying and pulling up his legs as if in pain. Some of the mother's milk was sent to me for analysis, and in it Professor Bedson found 0·4 part of lead per million; he also found lead in the mother's urine.

Breast-feeding was discontinued, and from that moment the infant ceased to have pain and began to increase in weight. Had I not known of the endemic plumbism, a true diagnosis of the infant's condition might not have been made. The child might have gone on suffering, and probably would have died. Under treatment the mother also made a satisfactory recovery.

What Constitutes Lead Poisoning?

The Workmen's Compensation Act, and the claims by working men arising out of it have imposed duties upon medical practitioners not always easily discharged. The diagnosis of lead poisoning may be easy or it may be difficult. In Great Britain law has decided that certain diseases of occupation which have been scheduled shall be considered as accidents from a compensation point of view. When men and women who have been working in lead become ill they are naturally disposed to regard the illness as in some way or other dependent upon their occupation. The burden of proof that they are suffering from lead poisoning is thrown upon the workpeople. Should the claim be substantiated, the employer in whose service the previous twelve months were spent is liable for compensation. Since, however, plumbism is of gradual development, and a workman may have been employed in more than one lead factory during the previous twelve months, the liability is divided amongst the various employers. Given a history of work in lead, the presence of a blue line on the gums, history of colic, presence of anæmia, basophilia, double wrist-drop, and the detection of lead in the urine, there is no difficulty in diagnosing the malady as plumbism. The difficulty arises when most of the usual signs and symptoms of lead poisoning are absent. It is generally admitted that the presence of a blue line on the gums is no proof that the individual is suffering from plumbism. It is only a sign that there is lead in the system, or that the individual has been brought into contact with lead. On the other hand, the Burtonian line, when accompanied by other signs and symptoms, is most valuable so long as such a possible cause as bismuth, for example, can be excluded. Some physicians find in basophilia a reliable test of plumbism. When present it is of assistance.

I have not found basophilia the help it has been to other physicians. Personally, I rely more upon the detection of lead in the urine. Its presence therein is an indication that the metal is in the system, and is being eliminated. On the other hand, lead may be found in the urine of lead workers without the men betraying plumbism.

These men, however, are on the border-line. Let elimination be checked, and symptoms at any time may arise. The presence of lead in the urine occupies the same relationship to saturnism as Koch's bacillus does to tuberculosis, Eberth's bacillus to typhoid fever, and Klebs - Löffler bacillus to diphtheria. Men and women may be typhoid carriers, they may be distributing the germs everywhere, and spreading typhoid fever, while they themselves are not suffering from the disease. What then are they suffering from? With the word "suffering" we have come to associate too much the idea of pain, a sense of annoyance, or a feeling of discomfort, whereas it only means bearing or sustaining. A man who is unaccustomed to stimulants, and who has exceeded the limits of moderation on a particular occasion, is the subject of, or is said to be temporarily suffering from, alcoholic intoxication; but the man who keeps nipping all day long, and who is never drunk, may show fewer signs of intoxication, although of the two men he is the greater alcoholic, and the less likely to be brought back within the range of the normal. In a similar manner a man may have a blue line on his gums, and lead be present in the urine, without such a person suffering from plumbism. The child of a female lead worker dies shortly after birth, and in the internal organs lead is found. The mother had never been off ill, and yet her infant dies from the effects of plumbism, due to lead conveyed from the maternal blood. She is a lead carrier. There is the death from plumbism without the mother having exhibited symptoms, and yet she was not free from lead or the possible presentation of symptoms from it, for it occasionally happens that after a confinement such a mother becomes paralyzed in her arms, a condition which, setting aside possible obstetrical causes, is rightly or wrongly regarded as due to lead. When, we ask, did such a patient become lead-poisoned? Was it only when she developed paralysis? Or was she not passively lead-poisoned all the time? In this problem of lead poisoning it seems to me that we must get rid of complaints, and the expression of suffering immediately relative to lead, and deal with the effects of the metal generally. As in chronic alcoholism, so in plumbism the old lead worker who has never been off ill, who breaks down in health or dies without having shown the ordinary signs and symptoms of plumbism, is not less the victim of the malady and entitled to compensation than the man or woman who, a few months after taking up the work, has developed colic or wrist-drop. In a sense he is more entitled to compensation, for by his long term of service he has contributed more to the trade, and has cost his employer less than those men or women who have broken down in health in the earlier stages of their working career.

There is another question. It is not only that patients presenting obscure symptoms must have their symptoms carefully scrutinized, but also the complaints of those who consult medical men for the side issues of plumbism. A painter seeks medical advice for gout. This disease is known to be an indirect result of lead. It is also and much more frequently the result of constitutional causes and conditions in no way associated with lead. But for having worked in lead the probability is that the painter would not have had gout. Is such a patient entitled to compensation? Or take another illustration: contracted kidney is a recognized consequence of long exposure to lead. This form of Bright's disease might develop in a plumber, for example, just as in any other person, and be in no way connected with lead, but because it is a more frequent cause of death in persons exposed to lead than in other persons, saturnine nephritis has come to be recognized in a court of law as a disease of occupation, and compensation has been given to the relatives. Particularly is this so, when on chemical analysis lead has been found in the internal organs. On the other hand, the absence of lead in the internal organs does not prove that the case was not lead poisoning. In one of my own patients who died from acute saturnine encephalopathy no lead was found in the brain, and yet there was no doubt as to death having been caused by exposure to lead. Under any circumstances it is only a minute quantity of lead which is present in the body, and a more minute quantity still which is circulating in the blood and causing harm. It is impossible to give such a comprehensive definition of plumbism as will include all cases. In industrial plumbism two types of the malady are met with—active and latent. It is in latent plumbism that the difficulty of diagnosis arises, for a man who is passing lead in his urine may not be suffering at the time from plumbism, and yet at any moment active manifestations of the disease may show themselves even months after the individual has retired from the factory.

TREATMENT: PREVENTIVE.

The treatment of lead poisoning is preventive and curative. In making a tour of inspection of a white or a red lead factory, the workmen in some of the departments are observed to be paler than men employed in other occupations. Although they are pale and unhealthy-looking, and although also on their gums a delicate blue line is observed, these men are not suffering from plumbism. They are all able to follow their employment, for the bulk of the lead which is being taken into the system is not all being retained : elimination keeps pace with absorption. In the case of several of the workers it is a slender line which separates lead absorption from lead intoxication. A workman who has been for years daily absorbing and eliminating lead, who has been becoming paler and paler, is occupying a delicate position. A slight check to the activity of his emunctory organs, and what was until then a pre-saturnine condition—that is, a condition preparatory to, but not actually one of, saturnism—becomes gradually one of lead poisoning. It would be a prudent act on the part of factory surgeons and employers to give workmen who, judging from pre-saturnine cachexia, are thus brought to the verge of breaking down in health, a holiday for a fortnight two or three times a year, so that absorption of lead might be interrupted, and elimination promoted. The good effects of absence from work and rest are in some persons rapidly apparent. In lead factories where the economic conditions do not permit of the hands being given temporary respite from work, there should be alternation of employment. It is a mistake to keep workmen always in the white or red lead processes ; they should from time to time be transferred to the yard or given some outdoor kind of employment.

The British Home Office regulations compare most favourably with those of other countries, and on the whole they are attended to. As regards personal hygiene the workers are not always as true to themselves as they ought to be. The lead industry is considerably improved to what it was years ago, and there is an increasing desire on the part of most manufacturers to do all they reasonably can to render the trade as free from risk to health as possible. The abolition of female labour, and the substitution for it of male labour in dangerous processes, although resented at the time by some employers on the ground of derangement of work, difficulty of finding male labour, and expense, is now generally admitted to have been a step in the right direction. It has purified the industry, and averted suffering. Attention to details of personal cleanliness, the work of the day never begun without food having been taken, provision of ample washing and bathing facilities by owners, wearing of overalls by employees, change of clothing and of boots when work is finished, no eating when at work, nor until after washing, no chewing of tobacco, or of smoking when at work, are regulations which are productive of good.

Periodical but frequent medical examination of the workers, once a week of persons employed in dangerous processes, with power to suspend, has also been of signal service in reducing the number of cases of plumbism. It would pay employers to set aside a good room in the factory for the medical examination of the workers. The room should be bright and with plenty of daylight admitted by a window in the roof. Since dust is the enemy of the worker, all efforts must be made to render the workrooms as free from dust as possible, either by improving methods of manufacture, whereby little or no dust is generated, by preventing its escape into the workroom, or its removal therefrom by means of fans. Fumes should be similarly dealt with. Hearty co-operation of employer and employed in regard to regulations is a necessity. In the arts and sciences lead cannot be readily dispensed with. Where possible it is desirable, from a health point of view, that a substitute should be found for lead. It is, however, not total abolition of lead that is called for so much as more hygienic methods of its manufacture, always remembering that lead compounds, wherever and whenever handled or operated upon, are products of a distinctly poisonous character. The prevention of plumbism should begin not after the men have entered a factory, but before they commence work in it. A cursory medical examination of applicants for work is not enough. It must be thorough.

At one of the large lead factories in Newcastle-upon-Tyne Dr. Irvine has instituted a procedure to which I have already drawn attention. It is well worthy of being adopted elsewhere. Any person applying for work is not only questioned as to his health and previous occupation, but his mouth and teeth are examined, and their condition noted; the urine is tested for albumin; a sphygmogram is taken, also a blood-pressure record. If, on applying for work, a man has a blood pressure of 140 millimetres Hg, such an applicant is refused. By these means Dr. Irvine has kept the works practically free from plumbism. By the substitution of mechanical and automatic methods for hand labour in the transference of raw white lead and the packing of finished lead products much has been gained from a health point of view, while in the manufacture of red lead, the introduction of minus pressure methods whereby air is drawn into the closed machinery rather than expelled from it, also the grinding and mixing of colours in closed machinery, have rendered the atmosphere of lead factories comparatively free from dust. In white lead factories the substitution of mechanical methods of filling and emptying the drying-stoves, the use of closed drying-ovens with inside peripheral canals into which the dried lead carbonate can be raked, have robbed drying of much of its dangers. In some white lead factories ovens or stoves have been dispensed with altogether. In making white lead paint it is not necessary to dry the lead first. The pigment removed from the white beds can be passed through crushers and washed, and afterwards passed on through a series of rollers between which the pulp comes into contact with oil. The water is gradually displaced by the oil, with the result that, practically speaking, a finished white lead paint containing only a mere trace of water escapes from the last cylinder. This method of directly treating the white lead obviates the necessity of handling the product and of drying it. In all dusty processes the shifts should not be too long, for if men are wearing respirators, and the work is hard, breathing becomes difficult, and the men become overheated. In cleaning out the flues of a lead-smelting factory, the men should not work longer than two hours at a stretch without having an hour's rest. A workman suspended on account of illness or indisposition should not, if he has been absent over a fortnight, be allowed to resume work in a lead factory without undergoing a medical examination as to the state of his health and physical fitness. Since some persons are more susceptible to lead than others, any indication of impending impairment of health should become cause for the medical examiner and employer removing a worker at once to outside labour. Since poverty and general deprivation predispose to plumbism, it is safer to draw workmen from the class above the abjectly poor. No person addicted to alcohol should be employed in lead. At the close of each shift the men before leaving the factory should carefully wash their hands and forearms, brush their nails, gargle the throat, and douche the nostrils with mild saline solution. At one large factory on Tyneside the men are given daily small chocolate-coated tabloids containing sulphide of soda. It is claimed that these possess a distinctly preventive influence against plumbism. Workers in lead should see to it that they do not suffer from constipation.

All lead factories should be so situated that the various workplaces can be freely flushed with currents of air. Plans for new lead factories should be submitted to the Home Office for confirmation and suggestion. For the maintenance of hygienic conditions inside a factory, several dust-collecting systems are in use to collect lead escaping into the air. Care must be taken to see that these exhaust pipes are kept clear, otherwise they get choked with dust, and become worse than useless. The cleaning of machinery, also the cleaning and chipping of the stones used for grinding and mixing white lead, are attended with danger. Every hopper and machine containing lead in the form of dust should be provided with a dust-exhaust. All melting-pots should be hooded. By ventilation and provision of exhausts wherever possible, respirators may be dispensed with. During structural alterations in lead factories the greatest care should be exercised, and all workmen, whether they belong to the factory or not, should be apprised of the dangers they may be exposed to, as the following case shows: A few years ago it was found necessary to enlarge the capacity of the plant in a white lead factory without stopping the manufacture. Large numbers of men were employed, and a foreman was appointed to superintend the work, so far as concerned keeping the labourers right in matters of cleanliness and the wearing of respirators. How signally this man failed in his duty the sequel shows. Not only did he himself become lead-poisoned, but within a space of two months there were forty cases of lead poisoning in the factory; two of the men died, two were paralyzed in hands and feet; in the remainder the symptoms were of a slighter character, so that they soon recovered. Most of the men who became poisoned were working on construction. By discharging all the intemperate men, hiring a special foreman and placing him in charge of the bathrooms, with instructions to report and cause to be discharged any man seen leaving the premises or eating without thoroughly washing himself and changing his clothes, by appointing a doctor to the works, and having a weekly medical examination, the results were highly satisfactory. No serious case of lead poisoning has occurred since then.

To prevent endemic plumbism caused by drinking-water gathered on peaty soils, water companies should have the deliveries tested for plumbo-solvency two or three times a year, so that proper amounts of chalk, limestone, or other correctives may be added; and to render water free from lead in the household supply the water should be passed through filters made from animal charcoal rich in phosphate.

Treatment: Curative.

As anæmia is an early sign of plumbism, a workman suspended from the factory should be encouraged to spend most of his time in the open air. He should be given a mild iron tonic, with or without magnesium sulphate. If colic is moderately severe it should be treated by application of warmth to the abdomen, or by a warm bath, and if there is sickness an effervescing soda and bismuth mixture containing a few drops of nepenthe should be given When there is obstinate constipation in addition to colic, castor oil is called for. Croton oil in 1-drop doses may be administered if constipation is extreme, but 1 ounce of olive oil in warm milk taken by the mouth, or a rectal enema of olive oil and warm water should be tried first. In some cases the abdominal pain is so severe as to call for the administration of morphia hypodermically. Even when the bowels have been freely opened by aperients the abdominal pain may continue for a few days. This type of pain is aggravated by pressure. It can be relieved by administering sodium monosulphite in ½ or 1 grain doses three or four times a day. On the recommendation of Dr. Stevens of Cardiff I have given with great relief to patients suffering from lead colic permanganate of calcium in ¼-grain doses thrice daily.

For colic a mixture of potassium iodide and magnesium sulphate is sometimes ordered. This should not be adopted as a routine treatment, for potassium iodide has the power of dissolving lead which has been lying inert and stored in the tissues, of causing it to circulate in the blood and thereby of intensifying the saturnine intoxication. As regards the treatment of wrist-drop, some patients find relief by resting the hand on a splint and carrying it in a sling. Massage and electricity give good results, either alone or combined with the internal administration of 2 or 3 minims of liquor strychniæ, or 5 minims or more of tincture of nux vomica. To the nux vomica mixture a few grains of iodide of potassium may be added. For epileptiform convulsions large doses of the bromides may be given by the mouth or by the rectum; nitrite of amyl may be inhaled, or lumbar puncture performed. An enema of mustard and warm water may be administered if, in addition to convulsions, there is constipation.

For chronic plumbism where there are anæmia, albuminuria, and such symptoms suggestive of interstitial nephritis as headache, imperfect vision, swollen features, and œdema of the feet, also emaciation, the medical treatment resolves itself into ordinary care of the patient and treatment of his symptoms generally. Opinions are divided as to whether, when a doctor detects albumin in the urine of an old lead worker in whom there is no doubt as to the existence of interstitial nephritis, such an individual should be compulsorily obliged to retire from work in the lead factory. Experience shows that men can go on working in a lead factory for years, and enjoy fairly good health, even though they are the subjects of chronic kidney disease, and experience equally shows when such men have been obliged to withdraw from the factory, that, owing to their diminished weekly income, as they are unable to obtain proper food, they worry and become ill. The detection of albumin in the urine of a comparatively young lead worker is another thing altogether. He ought to give up work in lead.

As a supplement to the preventive and curative treatment of plumbism, I should like to draw attention to another line of treatment with which the names of Mr. T. M. Clague, of Newcastle-upon-Tyne, and myself are associated. It is the double electrical bath treatment. Dr. Lewis Jones was kind enough a few years ago to contribute to my book, "Dangerous Trades," an article on the electrical treatment of plumbism. He showed how, under the single bath electrical treatment, patients, when paralyzed, made a quicker recovery than without it. Massage and medicinal treatment were by it rendered more effective. Patients who are the subjects of lead poisoning keep eliminating lead by the kidneys and by the bowels. Electrolysis causes lead to pass by a process akin to osmosis from the body to the electrodes in the bath in which the patient is immersed. The experimental evidence that lead can be extracted from the body of man by electrolysis is not free from sources of error, for the amount of the metal in the body at any time must be small, probably not more than a few grains, so that there would be in a dipolar bath—that is, a bath into which both poles are placed—considerable difficulty in finding measurable quantities of lead deposited on the electrodes in the bath. In the single bath the lead deposited on the positive pole appears as peroxide, and on the negative pole it is found, according to Dr. Lewis Jones, in a spongy metallic form. There is always the possibility of lead found in the bath-water having come from the skin of the workman. For example, it might be lead which had simply been lying on the surface of the body, or lead in the process of elimination by the glands of the skin, but admitting these as possible sources of the metal, there is not the least doubt that electrolysis favours the elimination of lead from the body by the skin.

In a paper* published a few months ago, I drew attention to the use of the double electrical bath which had been suggested to me by Mr. T. M. Clague, to whom I had applied for assistance as to the possibility of removing lead from a

* *Lancet*, August 23, 1913.

rabbit the subject of experimental lead poisoning. During the three years the animal was under observation he had received 1,096 grains of nitrate of lead, the equivalent of 684 grains of metallic lead. After having taken a few hundred grains of nitrate of lead, the animal became painlessly paralyzed. It was then that I asked whether, by means of electrolysis, lead could not be removed from the body of the animal, and the opportunity given to him of regaining health. As a result of the double electrical bath the paralysis quickly disappeared, and the animal made a good recovery. The fore-limbs of the animal were placed in one bath along with the negative pole, and the hind-limbs in another bath with the positive pole, the chest and abdomen of the animal resting on a soft cushion of cotton wadding. After a bath of an hour's duration lead was found on the negative electrode, and in the bath-water. Several weeks after the rabbit had regained its health and vigour, small doses of lead were again administered, with the result that the animal for a second time became paralyzed. Treated by the double electrical bath, the paralysis disappeared, and the rabbit was soon in the vigour of health once more. After a respite of a few months, lead administered for the third time caused paralysis: this was attended by progressive general emaciation and followed by death, the electrical bath treatment not having again been brought into operation. In the internal organs, especially in the spleen, considerable traces of lead were found.

The points of professional interest are the length of time the animal took lead, three years, also the large quantity of it, 1,096 grains of nitrate; twice recovery from paralysis, and restoration to health under the influence of electrical bath treatment. During life the fæces contained lead, showing that all the time the animal was receiving lead it was also eliminating it.

The theory of the action of the double electrical bath is as follows: when an electrical current is passed through a solution of a salt, the acid radicle collects upon the positive pole while the base travels to the negative. Thus $\frac{NaCl}{ZnSO_4}$ after passage of an electrical current appear as $\frac{Cl}{SO_4}$ at the positive pole, and $\frac{Na}{Zn}$ at the negative. The two entities in each salt are called *ions*. They possess the power of traversing membranes. When a solution containing them is applied to the skin, and an electrical current is passed at the same time, *ioniza-*

tion occurs. Introduction of metallic drugs into the human body by this means has been attended with distinct success. The method of application is as follows: The joint or limb about to be treated can either be placed in a bath containing the salt in solution, or a pad of lint soaked in the medicament can be laid upon the particular part, and an electrode laid upon it, while the other pole is applied to an indifferent part of the body. If a bath is used, more current can be passed, and as a consequence more *ions* can be introduced. Such in a few words is ionization. Electrical treatment of lead poisoning by the two-bath system is de-ionization. In this method of treatment the electrical current passes through the body: it breaks up any lead compound which may be present; it carries the acid radicle to the positive pole, and the base to the negative. The apparatus is simple. A wooden tub is required for the feet of the workman, and into it tepid water is placed, while for the hands and forearms similar provision is made. A series of tubs can be arranged so that several men can take the bath at one and the same time. The electrical part of the apparatus consists of a battery, a milliampèremeter, and a rheostat for regulating electrical pressure, also wires and electrodes in the form of grids. The bath is given for half an hour or a little longer every day or every second or third day, according to whether it is being used for curative or preventive purposes. A voltage of 16 is generally sufficient, and a milliampèrage of 20 to 40. The positive pole is placed in the foot-bath, and the negative in the arm-bath. The electrodes, made from aluminium, should be free from lead. If the electrical current, as regulated by the rheostat, is introduced gradually, no shock is felt, nor is any unpleasant sensation experienced by the men. On the other hand, if the hands or feet are brought into direct contact with the electrodes the skin may become red and painful, and ulceration even may follow. Care must therefore be taken by those using the bath that such accidents do not occur. Occasionally the skin becomes red and irritable at the water-level mark, due to disruption of the common salt added to the bath-water to reduce resistance to the passage of the electrical current.

Objections have been raised in regard to the electrolytic treatment of plumbism, the principal one being that there is no evidence to show that lead can be removed from the body. To that I unhesitatingly give the answer that lead has been detected on the electrodes and in the water after the baths. As the amount of lead in the body ot a workman at any particular time is extremely small only minute traces of the metal can be found. One disturbing circumstance in the electrical bath treatment of lead workers is the possible presence of the metal or its compounds on the skin. But where plumbism is due to drinking contaminated water, this possibility does not hold, and yet in patients thus suffering lead was found on the electrodes and in the bath-water. Another source of lead, apart from the patient about to be treated, is the water of the bath : this may have been taken from lead pipes ; and also there is the possibility of the common salt which was added to the bath having contained traces of lead. But apart from these, and where the greatest care was taken to eliminate all possible sources of error, lead has been found on the electrodes and in the water after the electrical bath treatment of lead workers.

At one of the large lead works in Newcastle-upon-Tyne an independent analytical chemist, Mr. H. Dunford Smith, was invited to arrange and supervise a double electrical bath, and to make an analysis of the grids and of the bath-water. A man who was working in the desilvering department, who had never been ill, whose gums did not show a blue line or his face pronounced anæmia, was selected by Mr. Dunford Smith for the experiment. It was felt that the test was a severe one, there being so many men in the works more likely to have been absorbing lead than this desilverer. One of the primary requirements was that the man must sit with feet and legs in warm water for an hour; also that the hands and forearms must be similarly immersed. The water was then to be changed. During the next part of the experiment the workman's limbs were simply to remain in the bath as before; the bath-water was to be removed and examined, fresh water was then to be placed in the tubs, and the electrical current turned on. The bath experiment lasted from one to two hours on two successive days. During the two days the man did no work in the factory. The following is a copy of the analysis by Mr. H. Dunford Smith:

	Lead in	
	Foot Water Gramme	Arm Water Gramme
January 15:		
Without current (no salt)	0·0005	0·0006
With current (100 grammes salt) ..	0·0044	0·0045
Aluminium grids	0·0003	0·00033
January 16:		
Without current (no salt)	0·0006	0·00083
With current (100 grammes salt) ..	0·0038	0·0057
Aluminium grids	None	0·00005

The urine was found to be free from lead.

From this man there was removed by electrolysis $\frac{1}{8}$ grain in the first day's bath, and in the second $\frac{1}{15}$ grain. This analysis from an independent and disinterested source is extremely valuable.

It was only to be expected that a line of treatment of plumbism so novel in some respects as that recommended by Mr. Clague and myself should be assailed and have to run the gauntlet of criticism. It is therefore encouraging to learn that in the United States not only is the electrical bath treatment of lead poisoning well known, but in the hands of some persons it has given satisfactory results. I extract from a letter sent to me by Dr. Francis D. Patterson, medical officer to Messrs. Harrison Bros., white lead and paint works in Philadelphia, also medical officer to the Electric Storage Battery Company, dated May 15, 1914, the following reference to the points under consideration:

"*Re* the electrolytic baths: I am using them as a routine method of prevention at these works and at the works of the Electric Storage Battery Company, and the results I am obtaining are in every way most gratifying, so much so that I am convinced it is the greatest advance which has ever been made in dealing with the problem of any occupational disease. I had a man who had acute lead colic, who was relieved after two hours in the bath, and another case, one of wrist-drop, in which, after three weeks' treatment, his paralysis is almost gone. In cases where I am using it as a precaution I have had analysis made of the water from the baths, and the following are some of the results:

Bath-Water.

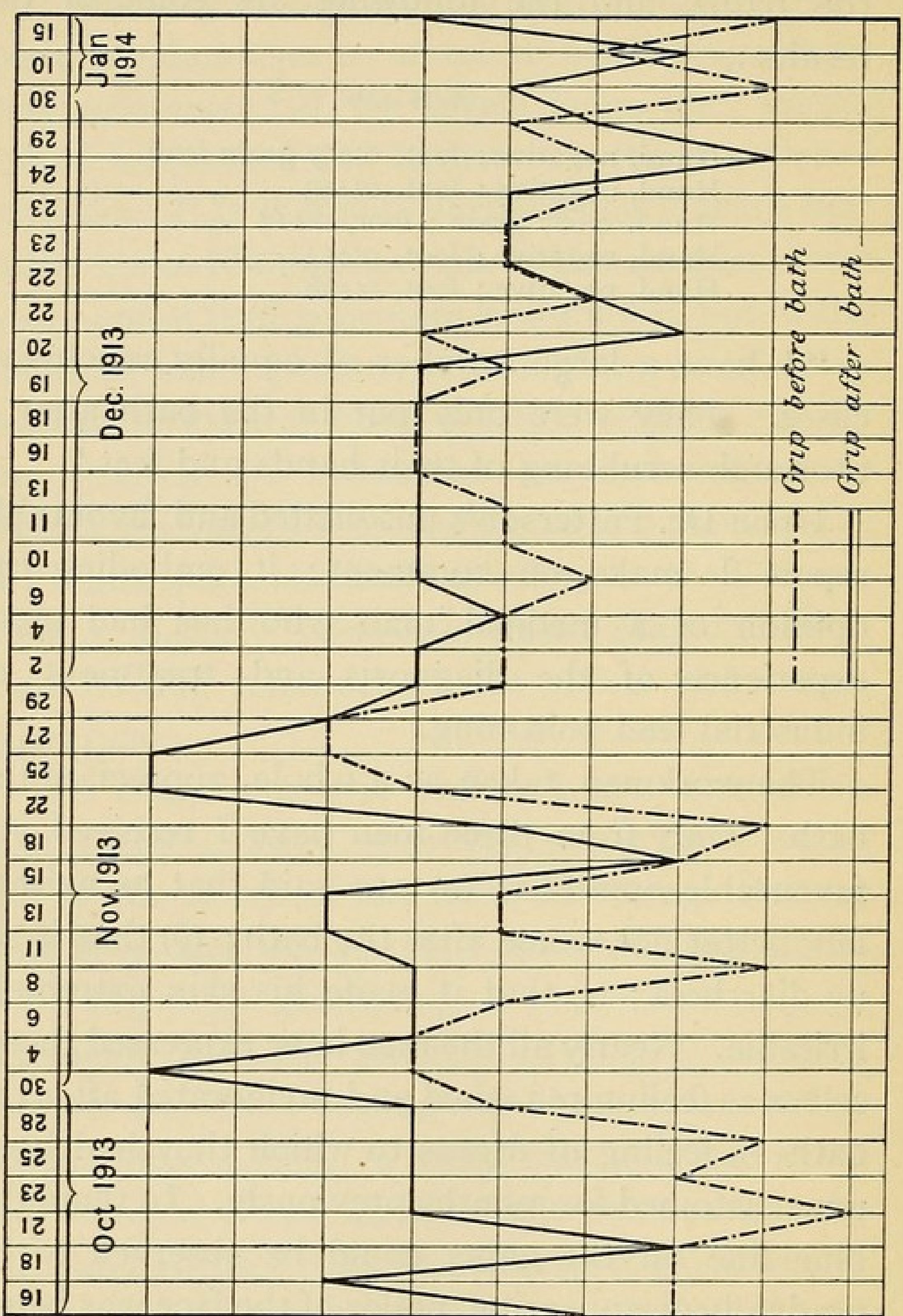
Hand, negative; foot, 0·057 grain lead.
Hand, negative; foot, 0·113 ,,
Hand, 0·087 grain; foot, 0·115 ,,
Hand, negative; foot, 0·453 ,,
Hand, negative; foot, 0·438 ,,

"I have a large number of equally conclusive cases. They were only put in the bath after a thorough scrubbing of their hands and feet."

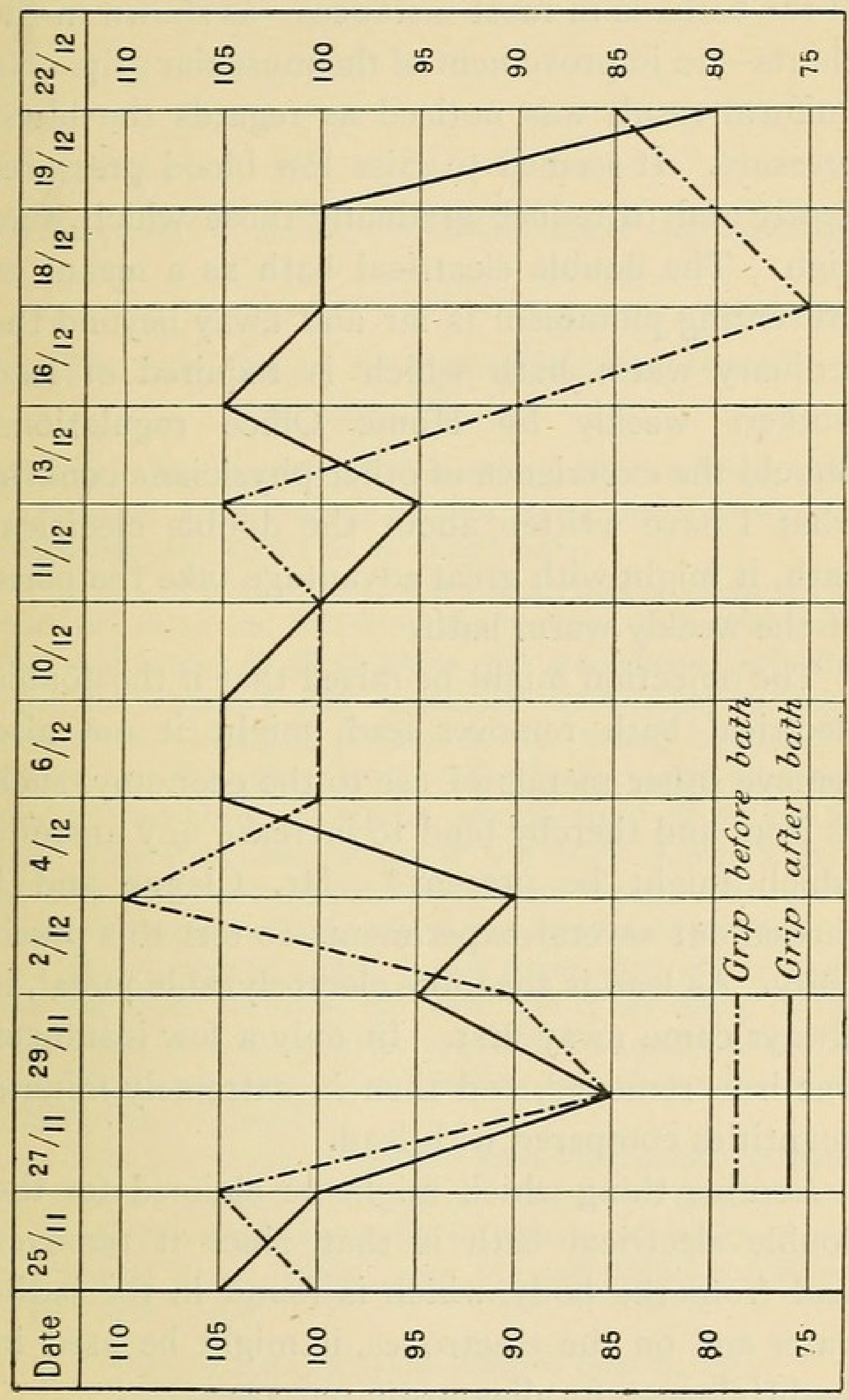
Upon Dr. Patterson's unsolicited and favourable report I make no comment: it embodies the opinion of a medical man who has had great experience of the diagnosis and treatment of industrial lead poisoning.

The workmen, taken as a whole, appreciate the bath. Only from three men have I received unfavourable opinions: (*a*) one said that he neither felt better nor worse after the bath; (*b*) that it set up diarrhœa; (*c*) that it made his skin extremely irritable. Nearly all the men have expressed themselves as feeling refreshed and invigorated after the bath—a feeling of fitness to which they had been unaccustomed for months previously. In them the blue line on the gums could be observed to be gradually disappearing, pallor of the face was being replaced by a ruddy glow of health, and the muscular power had considerably improved. The effect

Electrical Bath Treatment of Plumbism: Muscular Effects. (J. W. P.)



ELECTRICAL BATH TREATMENT OF PLUMBISM : MUSCULAR EFFECTS. (T. T.)



The figures to right and left indicate pounds weight.

of the baths is in most instances—as shown in the charts—an improvement of the muscular grip. No uniform result was noticed as regards the blood pressure. It seemed to raise low blood pressures gently and to reduce gradually those which were high. The double electrical bath as a means of preventing plumbism is far and away beyond the ordinary warm bath which is required of lead workers weekly by Home Office regulations. Should the experience of other physicians confirm what I have written about the double electrical bath, it might with great advantage take the place of the weekly warm bath.

The objection might be raised that if the double electrical bath removes lead, might it not also remove other metals of use to the economy, such as iron, and thereby tend to increase any anæmia which might be present? Mr. Clague and I carried out several experiments to test this possibility. As lead is the more electrolyzable metal, it always came away first. In only a few instances was iron removed, and then in extremely minute quantities compared with lead.

Another thing which might be claimed for the double electrical bath is that, since it removes lead from the body, which is found in the bath-water and on the electrodes, it might be used in doubtful cases for diagnostic purposes.

FACTORY AND WORKSHOP ORDERS

For the Process of File-Cutting by Hand.*

1903. No. 507.

Whereas the process of file-cutting by hand has been certified in pursuance of Section 79 of the Factory and Workshop Act, 1901,† to be dangerous;

I hereby, in pursuance of the powers conferred on me by that Act, make the following Regulations, and direct that they shall apply to all factories and workshops (including tenement factories and tenement workshops) or parts thereof in which the process of file-cutting by hand is carried on: Provided that the Chief Inspector of Factories may by certificate in writing exempt from all or any of these Regulations any factory or workshop in which he is satisfied that the beds used are of such composition as not to entail danger to the health of the persons employed.

1. The number of stocks in any room shall not be more than one stock for every 350 cubic feet of air space in the room; and in calculating air space for the purpose of this Regulation any space more than 10 feet above the room shall not be reckoned.

2. After the 1st day of January, 1904, the distance between the stocks measured from the centre of one stock to the centre of the next shall not be less than 2 feet 6 inches, and after the 1st day of January, 1905, the said distance shall not be less than 3 feet.

* These Regulations were gazetted June 23, 1903.

† 1 Edw. 7, c. 22.

3. Every room shall have a substantial floor, the whole of which shall be covered with a washable material, save that it shall be optional to leave a space not exceeding 6 inches in width round the base of each stock.

The floor of every room shall be kept in good repair.

4. Efficient inlet and outlet ventilators shall be provided in every room. The inlet ventilators shall be so arranged and placed as not to cause a direct draught of incoming air to fall on the workmen employed at the stocks.

The ventilators shall be kept in good repair and in working order.

5. No person shall interfere with or impede the working of the ventilators.

6. Sufficient and suitable washing conveniences shall be provided and maintained for the use of the file-cutters. The washing conveniences shall be under cover and shall comprise at least one fixed basin for every ten or less stocks. Every basin shall be fitted with a waste pipe discharging over a drain or into some receptacle of a capacity at least equal to one gallon for every file-cutter using the basin. Water shall be laid on to every basin either from the main or from a tank of a capacity of not less than 1½ gallons to every worker supplied from such tank. A supply of clean water shall be kept in the said tank while work is going on, at least sufficient to enable every worker supplied from such tank to wash.

7. The walls and ceiling of every room, except such parts as are painted or varnished or made of glazed brick, shall be limewashed once in every six months ending the 30th of June and once in every six months ending the 31st of December.

8. The floor and such parts of the walls and ceiling as are not limewashed and the benches shall be cleansed once a week.

9. If the factory or workshop is situated in a dwelling-house the work of file-cutting shall not be carried on in any room which is used as a sleeping place or for cooking or eating meals.

10. Every file-cutter shall when at work wear a long apron reaching from the shoulders and neck to below the knees. The apron shall be kept in a cleanly state.

11. A copy of these Regulations and an Abstract of the provisions of the Factory and Workshop Act, 1901,* shall be kept affixed in the factory or workshop in a conspicuous place.

12. It shall be the duty of the occupier to carry out Regulations 1, 2, 3, 4, 6, 7, and 11; except that, in any room in a tenement factory or tenement workshop which is let to more than one occupier, it shall be the duty of the owner to carry out these Regulations, except the last clause of Regulation 6, which shall be carried out by the occupiers.

It shall be the duty of the occupier or occupiers to carry out Regulation 8.

It shall be the duty of the occupier or occupiers and of every workman to observe Regulations 5, 9, and 10.

These Regulations shall come into force on the 1st day of September, 1903.

A. AKERS-DOUGLAS,
One of His Majesty's Principal
Secretaries of State.

Home Office, Whitehall,
19th June, 1903.

FOR THE MANUFACTURE OF ELECTRIC ACCUMULATORS.†
1903. No. 1004.

Whereas the manufacture of electric accumulators has been certified in pursuance of Section 79 of the Factory and Workshop Act, 1901,‡ to be dangerous;

I hereby, in pursuance of the powers conferred on me by that Act, make the following Regulations, and direct that they shall apply to all factories and workshops or parts thereof in which electric accumulators are manufactured.

* 1 Edw. 7, c. 22.

† These Regulations were gazetted November 24, 1903.

‡ 1 Edw. 7, c. 22.

In these Regulations "*lead process*"* means pasting, casting, lead burning, or any work involving contact with dry compounds of lead.

Any approval given by the Chief Inspector of Factories in pursuance of these Regulations shall be given in writing, and may at any time be revoked by notice in writing signed by him.

Duties of Occupier.

1. Every room in which casting, pasting, or lead burning is carried on shall contain at least 500 cubic feet of air space for each person employed therein, and in computing this air space, no height above 14 feet shall be taken into account.

These rooms and that in which the plates are formed, shall be capable of through ventilation. They shall be provided with windows made to open.

2. Each one of the following processes shall be carried on in such manner and under such conditions as to secure effectual separation from one another and from any other process :

(*a*) Manipulation of dry compounds of lead;
(*b*) Pasting;
(*c*) Formation, and lead burning necessarily carried on therewith;
(*d*) Melting down of old plates.

Provided that manipulation of dry compounds of lead carried on as in Regulation 5 (*b*) need not be separated from pasting.

3. The floors of the rooms in which manipulation of dry compounds of lead or pasting is carried on shall be of cement or similar impervious material, and shall be kept constantly moist while work is being done.

The floors of these rooms shall be washed with a hose pipe daily.

* The term "lead process" to which a defined meaning is given is printed throughout in italics.

4. Every melting pot shall be covered with a hood and shaft so arranged as to remove the fumes and hot air from the workrooms.

Lead ashes and old plates shall be kept in receptacles specially provided for the purpose.

5. Manipulation of dry compounds of lead in the mixing of the paste or other processes, shall not be done except (*a*) in an apparatus so closed, or so arranged with an exhaust draught, as to prevent the escape of dust into the workroom; or (*b*) at a bench provided with (1) efficient exhaust draught and air guide so arranged as to draw the dust away from the worker, and (2) a grating on which each receptacle of the compound of lead in use at the time shall stand.

6. The benches at which pasting is done shall be covered with sheet lead or other impervious material, and shall have raised edges.

7. No woman, young person, or child shall be employed in the manipulation of dry compounds of lead or in pasting.

8. (*a*) A duly qualified medical practitioner (in these Regulations referred to as the "Appointed Surgeon") who may be the Certifying Surgeon, shall be appointed by the occupier, such appointment unless held by the Certifying Surgeon to be subject to the approval of the Chief Inspector of Factories.

(*b*) Every person employed in a *lead process* shall be examined once a month by the Appointed Surgeon, who shall have power to suspend from employment in any *lead process*.

(*c*) No person after such suspension shall be employed in a *lead process* without written sanction entered in the Health Register by the Appointed Surgeon. It shall be sufficient compliance with this Regulation for a written certificate to be given by the Appointed Surgeon and attached to the Health Register, such certificate to be replaced by a proper entry in the Health Register at the Appointed Surgeon's next visit.

(*d*) A Health Register in a form approved by the Chief

Inspector of Factories shall be kept, and shall contain a list of all persons employed in *lead processes*. The Appointed Surgeon will enter in the Health Register the dates and results of his examinations of the persons employed and particulars of any directions given by him. He shall on a prescribed form furnish to the Chief Inspector of Factories on the 1st day of January in each year a list of the persons suspended by him during the previous year, the cause and duration of such suspension, and the number of examinations made.

The Health Register shall be produced at any time when required by H.M. Inspectors of Factories or by the Certifying Surgeon or by the Appointed Surgeon.

9. Overalls shall be provided for all persons employed in manipulating dry compounds of lead or in pasting.

The overalls shall be washed or renewed once every week.

10. The occupier shall provide and maintain—

(*a*) A cloakroom in which workers can deposit clothing put off during working hours. Separate and suitable arrangements shall be made for the storage of the overalls required in Regulation 9.

(*b*) A dining-room unless the factory is closed during meal hours.

11. No person shall be allowed to introduce, keep, prepare or partake of any food, drink, or tobacco, in any room in which a *lead process* is carried on. Suitable provisions shall be made for the deposit of food brought by the workers.

This Regulation shall not apply to any sanitary drink provided by the occupier and approved by the Appointed Surgeon.

12. The occupier shall provide and maintain for the use of the persons employed in *lead processes* a lavatory, with soap, nail brushes, towels, and at least one lavatory basin for every five such persons. Each such basin shall be provided with a waste pipe, or the basins shall be placed on a trough fitted with a waste pipe. There shall be a constant supply of hot and cold water laid on to each basin.

Or, in the place of basins the occupier shall provide and maintain troughs of enamel or similar smooth impervious material, in good repair, of a total length of two feet for every five persons employed, fitted with waste pipes, and without plugs, with a sufficient supply of warm water constantly available.

The lavatory shall be kept thoroughly cleansed and shall be supplied with a sufficient quantity of clean towels once every day.

13. Before each meal and before the end of the day's work, at least ten minutes, in addition to the regular meal times, shall be allowed for washing to each person who has been employed in the manipulation of dry compounds of lead or in pasting.

Provided that if the lavatory accommodation specially reserved for such persons exceeds that required by Regulation 12, the time allowance may be proportionately reduced, and that if there be one basin or two feet of trough for each such person this Regulation shall not apply.

14. Sufficient bath accommodation shall be provided for all persons engaged in the manipulation of dry compounds of lead or in pasting, with hot and cold water laid on, and a sufficient supply of soap and towels.

This rule shall not apply if in consideration of the special circumstances of any particular case, the Chief Inspector of Factories approves the use of local public baths when conveniently near, under the conditions (if any) named in such approval.

15. The floors and benches of each workroom shall be thoroughly cleansed daily, at a time when no other work is being carried on in the room.

Duties of Persons Employed.

16. All persons employed in *lead processes* shall present themselves at the appointed times for examination by the Appointed Surgeon as provided in Regulation 8.

No persons after suspension shall work in a *lead process,* in any factory or workshop in which electric accumulators are manufactured, without written sanction entered in the Health Register by the Appointed Surgeon.

17. Every person employed in the manipulation of dry compounds of lead or in pasting shall wear the overalls provided under Regulation 9. The overalls, when not being worn, and clothing put off during working hours, shall be deposited in the places provided under Regulation 10.

18. No person shall introduce, keep, prepare, or partake of any food, drink (other than any sanitary drink provided by the occupier and approved by the Appointed Surgeon), or tobacco, in any room in which a *lead process* is carried on.

19. No person employed in a *lead process* shall leave the premises or partake of meals without previously and carefully cleaning and washing the hands.

20. Every person employed in the manipulation of dry compounds of lead or in pasting shall take a bath at least once a week.

21. No person shall in any way interfere, without the concurrence of the occupier or manager, with the means and appliances provided for the removal of the dust or fumes, and for the carrying out of these Regulations.

These Regulations shall come into force on the 1st day of January, 1904.

A. Akers-Douglas,
One of His Majesty's Principal
Secretaries of State.

Home Office, Whitehall,
21st November, 1903.

For the Manufacture of Paints and Colours.*
1907. No. 17.

Whereas the manufacture of paints and colours has been certified in pursuance of Section 79 of the Factory and Workshop Act, 1901,† to be dangerous ;

* These Regulations were gazetted January 25, 1907.
† 1 Edw. 7, c. 22.

I hereby in pursuance of the powers conferred on me by that Act make the following Regulations, and direct that they shall apply to all factories and workshops in which dry carbonate of lead or red lead is used in the manufacture of paints and colours or chromate of lead is produced by boiling, provided as follows ;

(1) The Regulations shall not apply to factories and workshops in which paints and colours are manufactured, not for sale, but solely for use in the business of the occupier ; or to factories or workshops in which only the manufacture of artists' colours is carried on ; or to the manufacture of varnish paints.

(2) Regulation 2, and so much of Regulation 3 as prevents the employment of a woman in manufacturing *lead colour*, shall not apply to the packing in parcels or kegs not exceeding 14 lb. in weight, unless and until so required by notice in writing from the Chief Inspector of Factories.

(3) Regulations 4, 5, 6, 11, and 12 shall not apply to factories or workshops in which the grinding of *lead colour* occupies less than three hours in any week, unless and until so required by notice in writing from the Chief Inspector of Factories.

*Definitions.**

For the purpose of these Regulations—

"*Lead colour*" means dry carbonate of lead and red lead, and any colour into which either of these substances enters.

"*Lead process*" means any process involving the mixing, crushing, sifting, grinding in oil, or any other manipulation of *lead colour* giving rise to dust ; or the manufacture and manipulation of chromate of lead produced by boiling in the colour house.

It shall be the duty of the occupier to observe Part I. of these Regulations.

* The terms "lead colour" and "lead process" to which defined meanings are given are printed throughout in italics.

It shall be the duty of all persons employed to observe Part II. of these Regulations.

Part I.

Duties of Employers.

1. No *lead colour* shall be placed in any hopper or shoot without an efficient exhaust draught and air guide so arranged as to draw the dust away from the worker as near as possible to the point of origin.

2. No *lead process* shall be carried on, save either—

   (*a*) with an efficient exhaust draught and air guide so arranged as to carry away the dust or steam as near as possible to the point of origin ; or

   (*b*) in the case of processes giving rise to dust, in an apparatus so closed as to prevent the escape of dust.

Provided that this Regulation shall not apply to the immersion and manipulation of *lead colour* in water.

3. No woman, young person, or child shall be employed in manipulating *lead colour.*

4. Every person employed in a *lead process* or at the roller mills connected with the grinding in oil of *lead colour* (hereinafter referred to as the *roller mills* *) shall once in each calendar month, on a date of which notice shall be given to every such person, be examined by the Certifying Surgeon of the district or other duly qualified medical practitioner (hereinafter referred to as the Appointed Surgeon) if appointed for the purpose by the Chief Inspector of Factories by a certificate under his hand and subject to such conditions as may be specified in that certificate.

The Certifying or Appointed Surgeon shall have power to suspend from employment in any *lead process* or at the *roller mills.*

5. No person after suspension in accordance with Regula-

* The term "roller mills" to which a defined meaning is given is printed throughout in italics.

tion 4 shall be employed in any *lead process* or at the *roller mills* without written sanction entered in the Health Register by the Certifying or Appointed Surgeon.

6. A Health Register in a form approved by the Chief Inspector of Factories shall be kept and shall contain a list of all persons employed in any *lead process* or at the *roller mills.* The Certifying or Appointed Surgeon will enter therein the dates and results of his examinations of such persons with particulars of any directions given by him.

The Health Register shall be produced at any time when required by any of His Majesty's Inspectors of Factories or by the Certifying or Appointed Surgeon.

7. Overalls shall be provided for all persons employed in *lead processes* or at the *roller mills ;* and shall be washed or renewed at least once every week.

8. The occupier shall provide and maintain for the use of all persons employed in *lead processes* or at the *roller mills*—

(*a*) a cloakroom or other suitable place in which such persons can deposit clothing put off during working hours, and separate and suitable arrangements for the storage of overalls required by Regulation 7 ;

(*b*) a dining-room, unless all workers leave the factory during meal hours.

9. No person shall be allowed to introduce, keep, prepare, or partake of any food, drink (other than a medicine provided by the occupier and approved by the Certifying or Appointed Surgeon), or tobacco in any room in which a *lead process* is carried on. Suitable provision shall be made for the deposit of food brought by persons employed.

10. The occupier shall provide and maintain in a cleanly state and in good repair for the use of persons employed in *lead processes* or at the *roller mills* a lavatory containing either—

(*a*) at least one lavatory basin for every five such persons, fitted with a waste pipe, or placed in a trough having a waste pipe, and having a constant supply of cold water laid on and a sufficient supply of hot water constantly available ; or

(*b*) troughs of enamel or similar smooth impervious material, fitted with waste pipes without plugs, and having a constant supply of warm water laid on. The length of such troughs shall be in a proportion of not less than two feet for every five persons employed in *lead processes* or at the *roller mills*.

He shall also provide in the lavatory soap, nail brushes, and a sufficient supply of clean towels renewed daily.

Part II.

Duties of Persons Employed.

11. All persons employed in *lead processes* or at the *roller mills* shall present themselves at the appointed time for examination by the Certifying or Appointed Surgeon as provided in Regulation 4.

12. No person after suspension under Regulation 4 shall work in a *lead process* or at the *roller mills* in any paint and colour factory or workshop to which these Regulations apply without written sanction entered in the Health Register by the Certifying or Appointed Surgeon.

13. All persons employed in *lead processes* or at the *roller mills* shall wear the overalls provided under Regulation 7 and shall deposit such overalls and any clothing put off during working hours in the places provided under Regulation 8.

The overalls shall not be removed by persons employed from the factory or worshop.

14. No person shall introduce, keep, prepare, or partake of any food, drink (other than a medicine provided by the occupier and approved by the Certifying or Appointed Surgeon), or tobacco in any room in which a *lead process* is carried on.

15. All persons employed in *lead processes* or at the *roller*

mills shall carefully clean and wash their hands before leaving the premises or partaking of any food.

16. No person shall, without the permission of the occupier or manager, interfere in any way with the means and appliances provided for the removal of dust, steam, or fumes, and for the carrying out of these Regulations.

These Regulations shall come into force on 1st February 1907.

H. J. GLADSTONE,
One of His Majesty's Principal
Secretaries of State.

Home Office, Whitehall,
January 21, 1907.

FOR THE HEADING OF YARN DYED BY MEANS OF A LEAD COMPOUND.*

1907. No. 616.

Whereas the process of *heading* of yarn dyed by means of a lead compound has been certified in pursuance of Section 79 of the Factory and Workshop Act, 1901,† to be dangerous;

I hereby, in pursuance of the powers conferred on me by that Act, make the following Regulations, and direct that they shall apply to all factories in which the said process is carried on.

Provided that if the Chief Inspector of Factories is satisfied, with regard to any such factory, that the *heading* of yarn dyed by means of a lead compound will not occupy more than three hours in any week, he may, by certificate, suspend Regulations 2, 3, 4, 7 (*a*), and 8 (*a*), or any of them. Every such certificate shall be in writing, signed by the Chief Inspector of Factories, and shall be revocable at any time by further certificate.

* These Regulations were gazetted August 13, 1907.

† 1 Edw. 7, c. 22.

*Definitions.**

"*Heading*" means the manipulation of yarn dyed by means of a lead compound over a bar or post, and includes picking, making-up, and noddling.

"*Employed*" means employed in *heading* of yarn dyed by means of a lead compound.

"*Surgeon*" means the Certifying Factory Surgeon of the district or a duly qualified medical practitioner appointed by certificate under the hand of the Chief Inspector of Factories, which appointment shall be subject to such conditions as may be specified in that certificate.

"*Suspension*" means suspension by written certificate in the Health Register, signed by the *Surgeon*, from employment in *heading* of yarn dyed by means of a lead compound.

Duties.

It shall be the duty of the occupier to observe Part I. of these Regulations.

It shall be the duty of all persons *employed* to observe Part II. of these Regulations.

PART I.

Duties of Employers.

1. No yarn dyed by means of a lead compound shall be *headed* unless there be an efficient exhaust draught so arranged as to draw the dust away from the worker, as near as possible to the point of origin. The speed of the draught at the exhaust opening shall be determined at least once in every three months and recorded in the General Register.

2. No person under 16 years of age shall be *employed*.

3. A Health Register, containing the names of all persons *employed*, shall be kept in a form approved by the Chief Inspector of Factories.

* Terms to which defined meanings are given are printed throughout in italics.

4. Every person *employed* shall be examined by the *Surgeon* once in every three months (or at shorter intervals if and as required in writing by the Chief Inspector of Factories) on a date of which due notice shall be given to all concerned.

The *Surgeon* shall have power of *suspension* as regards all persons *employed*, and no person after *suspension* shall be *employed* without written sanction from the *Surgeon* entered in the Health Register.

5. There shall be provided and maintained for the use of all persons *employed*—

(*a*) a suitable cloakroom for clothing put off during working hours;

(*b*) a suitable meal-room separate from any room in which *heading* of yarn dyed by means of a lead compound is carried on, unless the works are closed during meal hours;

and, if so required by notice in writing from the Chief Inspector of Factories,

(*c*) suitable overalls and head-coverings which shall be collected at the end of every day's work, and be washed and renewed at least once every week;

(*d*) a suitable place, separate from the cloakroom and meal-room, for the storage of the overalls and head-coverings.

6. There shall be provided and maintained in a cleanly state and in good repair, for the use of all persons *employed*, a lavatory, under cover, with a sufficient supply of clean towels, renewed daily, and of soap and nail brushes, and with either—

(*a*) a trough with a smooth impervious surface, fitted with a waste pipe without plug, and of such length as to allow at least two feet for every five such persons, and having a constant supply of warm water from taps or jets above the trough at intervals of not more than two feet; or (*b*) at least one lavatory basin for every five such persons, fitted with a waste pipe and plug or placed in a trough having a waste pipe, and having either a constant supply of hot and cold water or warm water laid on, or (if a constant supply of heated water be not reasonably practicable) a constant supply of cold water laid on and a supply of hot water always at hand when required for use by persons *employed.*

Part II.

Duties of Persons Employed.

7. Every person *employed* shall—

(*a*) present himself at the appointed time for examination by the *Surgeon* as provided in Regulation 4;

(*b*) wear the overall and head-covering (provided in pursuance of Regulation 5 (*c*)) while at work, and shall remove them before partaking of food or leaving the premises, and shall deposit in the cloakroom, provided in pursuance of Regulation 5 (*a*), clothing put off during working hours;

(*c*) wash the hands before partaking of food or leaving the premises.

8. No person shall—

(*a*) work in *heading* of yarn dyed by means of a lead compound after *suspension,* without written sanction from the *Surgeon* entered in the Health Register;

(*b*) introduce, keep, prepare, or partake of any food or drink, or tobacco, in any room in which *heading* of yarn dyed by means of a lead compound is carried on;

(*c*) interfere in any way, without the concurrence of the occupier or manager, with the means and appliances provided for the removal of the dust, and for the carrying out of these Regulations.

H. J. GLADSTONE,
One of His Majesty's Principal
Secretaries of State.

Home Office, Whitehall,
6th August, 1907.

FOR THE SMELTING OF MATERIALS CONTAINING LEAD, THE MANUFACTURE OF RED OR ORANGE LEAD, AND THE MANUFACTURE OF FLAKED LITHARGE.*

1911. No. 752.

In pursuance of Section 79 of the Factory and Workshop Act, 1901,† I hereby make the following Regulations, and direct that they shall apply to all factories and workshops or parts thereof (other than laboratories), in which any of the following processes are carried on :—

THE SMELTING OF MATERIALS CONTAINING LEAD ;
THE MANUFACTURE OF RED OR ORANGE LEAD ;
THE MANUFACTURE OF FLAKED LITHARGE.

These Regulations shall come into force on October 1st, 1911, except that so much of Regulations 2 and 3 as requires the provision of *efficient exhaust draught* shall come nto force on May 1st, 1912.

Definitions.‡

In these Regulations :—

"*Lead material*" means—

(i.) material containing not less than five per cent. of lead, including lead ore, bullion ore (lead ore rich in precious metals), red lead, orange lead, and flaked litharge, and

* These Regulations were gazetted August 18, 1911.

† 1 Edw. 7, c. 22.

‡ Terms to which defined meanings are given are printed throughout the Regulations in italics.

(ii.) zinc ore, and material resulting from the treatment thereof, containing not less than two per cent. of lead;

except ores which contain lead only in the form of sulphide of lead.

"*Furnace*," "*melting pot*," "*retort*," "*condensing chamber*," mean structures as aforesaid which are used in the treatment of *lead material*.

"*Flue*" means a flue leading from a *furnace*.

"*Lead process*" means—

(i.) manipulation, movement or other treatment of *lead material*, whether by means of any *furnace*, *melting pot*, *retort*, *condensing chamber*, *flue*, or otherwise; and

(ii.) cleaning or demolition of any *furnace*, *melting pot*, *retort*, *condensing chamber*, *flue*, or part thereof or reconstruction thereof with material which has formed part of any such structure.

"*Surgeon*" means the Certifying Factory Surgeon of the district or a duly qualified medical practitioner appointed by written certificate of the Chief Inspector of Factories, which appointment shall be subject to such conditions as may be specified in that certificate.

"*Suspension*" means suspension from employment in any *lead process* by written certificate in the Health Register, signed by the *Surgeon*, who shall have power of suspension as regards all persons employed in any *lead process*.

"*Damp*" means sufficiently moist to prevent the escape of dust.

"*Efficient exhaust draught*" means localized ventilation effected by heat or mechanical means, for the removal of gas, vapour, fumes or dust so as to prevent them (as far as practicable under the atmospheric conditions usually prevailing) from escaping into the air of any place in which work is carried on. No draught shall be deemed efficient which fails so to remove smoke generated at the point where such gas, vapour, fumes or dust originate.

Duties.

It shall be the duty of the occupier to observe Part I. of these Regulations.

It shall be the duty of every person employed to observe Part II. of these Regulations.

Part I.—Duties of Occupiers.

1. Where a *lead process* is carried on so as to give rise to dust or fumes,

(*a*) the floor, other than sand beds, shall be maintained in good condition; and

(*b*) the floor, except such portion as is permanently set apart for the deposit of *lead material*, shall be sprayed with water at least once a day.

2. (1) No *lead material* (other than ingots of metal) shall be deposited or allowed to remain on any part of the floor not permanently set apart for the purpose, and no *lead material* (other than ingots of metal) shall be moved to a *furnace*, unless such *lead material* is—

(*a*) *damp*; or

(*b*) under an *efficient exhaust draught*; or

(*c*) so enclosed as to prevent the escape of dust into the air of any place in which work is carried on.

(2) Provided, however, that where none of the above conditions are practicable, *lead material* may be moved to a *furnace* by persons wearing suitable respirators.

3. None of the following processes shall be carried on except with an *efficient exhaust draught*:—

melting old or dirty scrap lead;
heating *lead material* so that vapour containing lead is given off;
cooling molten flaked litharge;

or, unless carried on in such manner as to prevent escape of gas, vapour, fumes or dust into any place in which work is carried on—

feeding any *furnace* or *retort ;*
manipulating *lead material* in any *furnace* or *retort ;*
removing *lead material* from any *furnace* or *retort ;*
placing in any hopper or shoot, or packing, red or orange lead or flaked litharge.

4. No sack which has contained *lead material* shall be cleaned, and, except in the process of sampling, no *lead material* shall be broken up, crushed or ground, unless such sack or *lead material* is *damp*, or is placed in an apparatus so enclosed as to prevent the escape of dust.

5. No *lead material* giving off vapour containing lead shall be removed from the *efficient exhaust draught* required by Regulation 3, unless in a receptacle with an efficient cover.

6. No person shall be allowed to enter any *furnace, melting pot, retort, condensing chamber,* or *flue,* until it has been ventilated.

7. No person shall be allowed to remain in any *flue* (unless *damp*) or *condensing chamber* for more than three hours without an interval of at least half an hour.

8. There shall be provided suitable overalls for the use of all persons employed in any of the following processes ; which overalls, when required for such use, shall be washed, cleaned or renewed at least once every week :—

(*a*) cleaning any *flue* (unless *damp*) or *condensing chamber ;*

(*b*) demolishing any part of a *furnace, melting pot, retort, condensing chamber,* or *flue,* unless either *damp* or under an *efficient exhaust draught ;*

(*c*) reconstructing any part of a *furnace, melting pot, retort, condensing chamber,* or *flue,* with material which has formed part of any such structure, unless *damp ;*

(*d*) breaking up, crushing, or grinding, in the process of sampling, *lead material,* unless either *damp* or placed in an apparatus so enclosed as to prevent the escape of dust ;

(*e*) placing in any hopper or shoot, or packing, red or orange lead or flaked litharge.

9. There shall be provided suitable respirators for the use of all persons employed in any process named in Regulation 2 (2) or in Regulation 8; which respirators, when required for such use, shall be washed or renewed at least once every day.

10. No person under 16 years of age, and no female, shall be employed in any *lead process.*

11. There shall be provided and maintained for the use of all persons employed in any *lead process*:—

(*a*) a suitable meal-room, unless the works are closed during meal hours;

(*b*) a suitable place or places for clothing put off during working hours; and

(*c*) a suitable place or places for the storage of overalls provided in pursuance of Regulation 8; which place or places shall be separate from those required by paragraphs (*a*) and (*b*) of this Regulation;

all of which shall be so located as not to be exposed to dust or fumes from any manufacturing process.

12. There shall be provided and maintained in a cleanly state and in good repair for the use of all persons employed in any *lead process*:—

(*a*) a lavatory, under cover, with a sufficient supply of clean towels, renewed daily, and of soap and nail brushes, and with either:—

(i.) a trough with a smooth impervious surface, fitted with a waste-pipe without plug, and of such length as to allow at least two feet for every five such persons employed at any one time, and having a constant supply of warm water from taps or jets above the trough at intervals of not more than two feet; or

(ii.) at least one lavatory basin for every five such persons employed at any one time, fitted with a waste-pipe and plug, and having either a constant supply of hot and cold water or warm water laid on, or (if a constant supply of heated water be not reasonably practicable) a constant supply of cold water laid on, and a supply of hot water always at hand when required for use by such persons ; and

(*b*) sufficient and suitable bath accommodation (douche or other) with hot water laid on, unless the water supply provided under paragraph (*a*) is so arranged that a warm douche for the face, neck and arms can be taken.

Provided that, when the number of persons so employed at any one time is temporarily increased by reason of *flue* cleaning, it shall not be necessary to provide (by reason only of such temporary increase) additional accommodation in pursuance of paragraph (*a*) of this Regulation if adequate time is allowed to all such persons for washing immediately before each meal (in addition to the regular meal times), and immediately before the end of the day's work.

13. (*a*) Every person employed in a *lead process* shall be examined by the *Surgeon* once in every calendar month (or at such shorter or longer intervals as may be prescribed in writing by the Chief Inspector of Factories) on a date of which due notice shall be given.

(*b*) A Health Register containing the names of all persons employed in any *lead process* shall be kept in a form approved by the Chief Inspector of Factories.

(*c*) No person after *suspension* shall be employed in any *lead process* without written sanction from the *Surgeon*, entered in the Health Register.

Part II.—Duties of Persons Employed.

14. (*a*) Every person employed in any *lead process* shall deposit in the place or places provided in pursuance of Regulation 11 (*b*) all clothing put off during working hours.

(*b*) Every person for whose use an overall is provided in pursuance of Regulation 8 shall wear the overall when employed in any process named in that Regulation, and remove it before partaking of food or leaving the premises, and deposit it in the place provided under Regulation 11 (*c*).

(*c*) Every person for whose use a respirator is provided in pursuance of Regulation 9, shall wear the respirator while employed in any process to which Regulation 2 (2) or Regulation 8 applies.

15. No person employed shall introduce, keep, prepare, or partake of any food or drink (other than a non-alcoholic drink approved by the *Surgeon*), or make use of tobacco, in any place in which any *lead process* is carried on ;

Provided that, except in processes named in Regulation 8, this Regulation shall not prevent any person from using tobacco, other than a cigar or cigarette, if his hands are free from lead.

16. Every person employed in any *lead process*, or in any place where any *lead process* is being carried on, shall, before partaking of food, wash the face and hands, and before leaving the premises, wash the face, neck, and arms, in the lavatory provided in pursuance of Regulation 12.

17. Every person employed in any *lead process* shall present himself at the appointed time for examination by the *Surgeon*, in pursuance of Regulation 13 (*a*).

18. No person employed shall, after *suspension* under these Regulations, or under any other Regulations or Special Rules applying to factories or workshops where any process involving the use of lead is carried on, work in any *lead process* without written sanction from the *Surgeon* entered in the Health Register.

19. No person employed shall interfere in any way, without the concurrence of the occupier or manager, with the means provided for the removal of gas, vapour, fumes, and dust, and for the carrying out of these Regulations.

W. S. CHURCHILL,
One of His Majesty's Principal
Secretaries of State

Home Office, Whitehall,
August 12, 1911.

For the Manufacture and Decoration of Pottery.*
1913. No. 2.

In pursuance of Section 79 of the Factory and Workshop Act, 1901,† I hereby make the following Regulations, and direct that they shall apply to all factories and workshops in which the manufacture or decoration of *pottery* or any process incidental thereto is carried on; including factories and workshops in which lithographic transfers, frits, or glazes are made for use in the manufacture or decoration of *pottery*.

Provided that, if at any time it is shown to the satisfaction of the Secretary of State in the case of any manufacture or process or any operation forming part thereof, that injury to health is adequately prevented by other appliances or under other conditions than those prescribed by these Regulations, he may, by Order, modify the whole or any part of the Regulations, so far as they apply to such manufacture or process. Any such Order may be revoked, modified, or extended by further Order.

And provided, further, in regard to Regulation 10 (*a*), the Secretary of State may, by Order—

(i.) grant exemptions from this Regulation in the case of any special branch of the industry if it can be shown that every means has been tried for the purpose of conforming to the prescribed limit;

(ii.) substitute a limit higher than 70° Fahrenheit in the case of printing or other specified shops, if it can be shown to be necessary.

Definitions.‡

In these Regulations:

"*Pottery*" includes earthenware, china, tiles, and any other articles made from clay, with or without the addition of other material.

* These Regulations were gazetted January 7, 1913.

† 1 Edw. 7, c. 22.

‡ Terms to which defined meanings are given are printed throughout in italics.

"*Coarse ware*" means *pottery* not shaped by compression of powdered material, and not fired more than once in the process of manufacture.

In the case of a fireclay works in which the ware is generally fired only once, the whole of the works may, with the approval in writing of the Chief Inspector of Factories, be regarded as a *coarse ware* factory, notwithstanding that some of the clay ware is hardened by fire before any slip or body coating is applied to the fireclay body; subject, however, to the following conditions:

(i.) no slip or body coating shall be applied before such hardening;

(ii.) neither the ware so hardened nor any subsequently applied slip or body coating shall be sandpapered or treated by any other process which would generate dust;

(iii.) the approval of the Chief Inspector of Factories shall be kept attached to the general register, and shall be subject to the further conditions, if any, specified therein, and shall be revocable by further notice in writing.

"*Leadless glaze*" means a glaze which does not contain more than one 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 five 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 1,000 times its weight of an aqueous solution of hydrochloric acid containing 0·25 per cent. of HCl. 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.

"*Galena*" means the native sulphide of lead containing not more than five per cent. of a soluble lead compound calculated as lead monoxide when determined in the manner described in the definition of *low solubility glaze. Galena* shall not for the purpose of these Regulations be deemed to be an unfritted lead compound.

"*Leadless glaze factory*" means a factory the occupier of which has given an undertaking, to the satisfaction of the Chief Inspector of Factories, that none but *leadless glaze* shall be used therein, and in which none but *leadless glaze* is in fact used.

"*Low solubility glaze factory*" means a factory the occupier of which has given an undertaking, to the satisfaction of the Chief Inspector of Factories, that none but *low solubility glaze* shall be used therein, and in which none but *low solubility glaze* is in fact used.

"*Majolica painting*" includes painting in majolica or other glaze.

"*Surgeon*" means the Certifying Factory Surgeon of the district, who shall have, as regards all persons examined by him in pursuance of these Regulations, power of *suspension* and of *permission to work*, by certificate which may either be *entered in the health register* by the *Surgeon* personally, or be sent by him to the occupier.

"*Entered in the health register*" means—

(*a*) Entered in the prescribed register kept at the factory in pursuance of Regulation 3; or

(*b*) Entered in the portable register prescribed for the use of casual workers.

"*Suspension*" means suspension, by signed certificate of the *Surgeon,* from employment in any process in which examination by the *Surgeon* is required by these Regulations.

"*Permission to work*" means permission, by signed certificate of the *Surgeon*, either—

(*a*) Terminating a *suspension,* or

(*b*) Permitting employment of a certain specified kind.

"*Potter's shops*" includes any place where tiles or other articles are made by pressing clay dust, as well as every place where articles *of pottery* are shaped by a plastic or other process.

"*Wedging of clay*" means the treatment of clay which has not been pugged or rolled, by raising one piece of clay by hand and bringing it down upon another piece; but does not include the process, frequently known as "slapping of clay," in which two pieces of clay, each small enough to be held in one hand, are slapped together.

"*Workroom*" shall not, for the purposes of Regulation 10, include any stove or drying chamber which is not entered by workers except for the purpose of carrying ware in or out or turning it.

"*Bedding*" means the placing of flat ware in powdered flint for the biscuit firing when the sagger or box containing the ware is filled up with powdered flint.

"*Flinting*" means the placing of flat ware in powdered flint for the biscuit firing when the sagger or box containing the ware is not filled up with powdered flint.

"*Scouring*" includes fine brushing, as well as sand-papering, brushing, and every other scouring process, as applied to biscuit ware.

"*Stopping of biscuit ware*" means the filling up of cracks in ware which has been fired once and before glaze is applied to it.

"*Glost placing*" includes the operations of carrying saggers of ware into the glost oven and carrying them out again after the glost firing, as well as the operation of placing the ware in the saggers for glost firing; but not placing of ware on cranks or similar articles prior to their transfer to saggers or kilns by other persons.

"*Flow material*" means any material containing lead, which is placed in saggers, with a view to its entire or partial volatilization during the glost firing of the ware.

"*Thimble picking*" means the picking over, sorting, or rearranging for further use, of thimbles, stilts, spurs, strips, saddles, or any similar articles which have been used for the support of articles of *pottery* during the process of glost firing.

"*Efficient exhaust draught*" used in connection with a process means an exhaust draught which effectually removes, as near as possible to the point of origin, the dust generated in the process. No draught shall be deemed to be efficient which fails effectually to remove smoke generated at any point where dust originates in the process.

PART I.—DUTIES OF OCCUPIERS.

1. *Age and Sex.*

(*a*) No women, young person, or child shall be employed in the following processes :

‡ (i.) *Stopping of biscuit ware* with a material which yields to dilute hydrochloric acid more than five 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 ;*

* (ii.) weighing out, shovelling, or mixing of unfritted lead compounds in the preparation or manufacture of frits, glazes, or colours ;

*† (iii.) lawning of glaze, except where less than a quart of glaze is lawned at a time for the worker's own use ;

‡ (iv.) preparation or weighing out of *flow material*,

(*) (‡) (v.) cleaning, as prescribed in Regulation 12, of floors of *potters' shops* or stoves or any place in which any process included in the Schedule is carried on ;

* (vi.) cleaning, as prescribed in Regulation 17, of boards used in the dipping house, dipper's drying room, ware cleaning room, or glost placing shop ;

*‡ (vii.) cleaning of mangles or any part thereof ;

‡ (viii.) washing of saggers with a wash which yields to dilute hydrochloric acid more than five per cent. of its dry weight of a soluble lead com-

* The Regulations in question are marked * ; or in case of partial or conditional exemption (*).

† The Regulations in question are marked † ; or in the case of partial or conditional exemption (†).

‡ The Regulations in question are marked ‡ ; or in case of partial or conditional exemption (‡).

pound calculated as lead monoxide when determined in the manner described in the definition of *low solubility glaze.*

(*b*) No young person or child, other than a male young person who wedges clay only for his own use, shall be employed in the *wedging of clay;* and no woman shall be so employed without a certificate of *permission to work.*

(*c*) No young person or child shall be employed in the carrying of clay, or other systematic carrying or lifting work, without a certificate of *permission to work,* specifying the maximum weight which he or she may carry; and no young person or child so employed shall be allowed to lift or carry any weight in excess of that named in the certificate. Provided that:—

(i.) No certificate shall permit the carrying of more than 30 lb. by anyone under 16 years of age; and

(ii.) No girl under 16 years of age and no boy under 15 years of age shall be allowed to carry clay, except that such a worker who is working for himself or herself, and is not an attendant of another worker, shall be allowed to carry such clay as is to be used by himself or herself in making articles of *pottery.*

(*d*) No female shall be employed for more than seven days as a wheel-turner for a thrower, without a certificate of *permission to work.*

(*e*) No girl under 16 years of age shall be employed as a lathe treader.

*† (*f*) No young person or child shall be employed as a dipper.

*† (*g*) No girl under 17 years of age and no boy under 16 years of age shall be employed as a dipper's assistant or ware cleaner.

*† (*h*) No woman, young person, or child shall be employed as a glost placer, except in the placing of china furniture or electrical fittings; and no girl under 17 years

of age and no boy under 16 years of age shall be employed as a glost placer in the placing of china furniture or electrical fittings. Except that male young persons over 16 years of age may be employed in the process of *glost placing* for the purpose of preparing saggers and assisting in the sagger-house during the drawing of ovens, provided that they shall not place any ware in the saggers.

*(*k*) In *low solubility glaze factories* :—

(i.) No person under 16 years of age shall be employed as a dipper ;

(ii.) No person under 15 years of age shall be employed as a dipper's assistant, ware cleaner, or glost placer.

(*) (‡) (*l*) Except as provided in Regulation 1 (*k*) (ii.) no person under 16 years of age shall be employed in any process included in Part I. of the Schedule ; and no person under 15 years of age shall be employed in any process included in Part II. of the Schedule.

(*m*) No female shall carry a sagger full of ware ; but

(i.) the moving of such a sagger from one part of a bench to a contiguous part of the same bench on the same level ; or

(ii.) the moving of such a sagger by any two females from a bench to the nearest convenient floor space in the same workroom if no saggers so moved are piled to a greater height than four feet,

shall not be deemed to be a contravention of this requirement.

2. *Periodical Examinations.*

(*) (†) (‡) (*a*) All persons employed in any process included in Part I. of the Schedule shall be examined once in each calendar month by the *Surgeon* ; and all persons employed in any process included in Part II. of the Schedule shall be examined once in every twelve months by the *Surgeon.*

(*b*) All persons for whom certificates of *permission to work* are required by Regulation 1 shall be examined by the *Surgeon* within seven days of the commencement of their employment in a process in which such a certificate is required.

(*c*) All young persons and children employed in the carrying of clay, or other systematic carrying or lifting work, shall be re-examined by the *Surgeon* twice in the first period of six months, and once in each period of six months thereafter until they attain the age of 18.

(*d*) Any female examined for employment as a wheel-turner shall be presented for re-examination at a later date, if the *Surgeon* considers it necessary.

(*) (†) (‡) (*e*) The fees for all medical examinations made in pursuance of these Regulations shall be paid by the employer and shall not be charged to the worker, whether he be in regular or casual employment. Provided that casual workers examined at the *Surgeon's* surgery shall pay a fee of one shilling for each certificate entered in the portable register; this fee shall be refunded by the occupier who first employs the worker after such examination; and the occupier shall record in the portable register the fact that the fee has been refunded.

(*) (†) (‡) (*f*) A notice shall be affixed in a prominent place in the factory, showing clearly the time appointed for the *Surgeon's* periodical visit; and an amending notice shall be affixed forthwith if it is found necessary to alter the date or hour; wherever possible, not less than three days' notice of a change of date shall be given.

(*) (†) (‡) (*g*) A private room shall be provided for all medical examinations. No one shall be present except such other medical man as the *Surgeon* may with the worker's consent admit; and in addition in the case of a female any one female relative may be present, or alternatively any one workwoman in the factory approved by the worker and the *Surgeon*.

(*) (†) (‡) (*h*) No person after *suspension* shall be allowed to work in any process in which examination by the *Surgeon* is required by these Regulations, without a certificate of *permission to work*.

3. *Health, etc., Register.*

(*) (†) (‡) (*a*) A register, in the form or forms prescribed, shall be kept, in which the *Surgeon* may enter the dates and results of his visits, the number of persons examined in pursuance of these Regulations, and particulars of any directions given by him. This register shall contain a correct list of all persons employed in the processes included in the Schedule, and of all persons for whom a certificate has been obtained in pursuance of Regulation 1; as well as all other particulars required to be entered in the register in pursuance of these Regulations.

(*) (†) (‡) (*b*) The register shall be open to the inspection of any worker so far as concerns the entries relating to that worker. All such entries as indicate the general health of the worker shall be so expressed as to be readily understood both by occupiers and persons employed.

(*) (†) (‡) (*c*) When a certificate of *suspension* or *permission to work* is sent by the *Surgeon* to the occupier, it shall be forthwith attached to the register, and shall be kept so attached until replaced by a personal entry by the *Surgeon* in the register.

4. *Overalls and Head-Coverings.*

(*) (‡) (*a*) The occupier shall provide and maintain suitable overalls and head-coverings for all persons employed in the processes included in the Schedule; except that head-coverings need not be provided for persons employed in *majolica painting* or *glost placing*.

(*) (‡) (*b*) Head-coverings shall be adequate to protect the hair from dust, and shall be worn in such a manner as to be effective for this purpose.

(*) (*c*) The occupier shall provide and maintain suitable aprons of a waterproof or similar material which can be sponged daily, for all dippers, dippers' assistants, and ware cleaners ; provided that, if the front of the overall supplied to any such worker in pursuance of these Regulations is made of a material which can be sponged daily, no separate apron need be provided for that worker.

(*) (‡) (*d*) No person shall be allowed to work in any process included in the Schedule without wearing the above-named overalls and head-coverings, as well as aprons when provided in pursuance of the preceding paragraph ; except that head-coverings need not be worn by persons employed in *majolica painting* or *glost placing.*

(*) (*e*) All aprons made of waterproof or similar material, and all overalls or parts of overalls made of such material, shall be thoroughly cleaned daily by the wearers by sponging or other wet process. All other overalls or parts of overalls and all head-coverings shall be washed or renewed at least once a week ; and the occupier shall provide for washing, renewal, and necessary repairs of all overalls and head-coverings to be done either at the factory or at a laundry ; and no worker shall be allowed to take home any overalls, head-coverings, or aprons provided in pursuance of these Regulations.

(*) (‡) (*f*) All overalls, head-coverings, and aprons provided in pursuance of these Regulations, when not in use or being washed and repaired, shall be kept in proper custody ; for this purpose there shall be provided a cupboard or cupboards or room or rooms suitably situated and sufficiently large to hold the overalls, head-coverings, and aprons ; a separate peg shall be provided for each worker who is required by these Regulations to wear overalls.

6. *Food.*

(*) (‡) (*a*) No person shall be allowed to keep, or prepare, or partake of any food, drink, or tobacco, or to remain during meal-times in any place in which is carried on any process included in the Schedule, or the process of towing, or the process of tile-making by the compression of dust, or any other process which the Inspector of Factories for the district shall certify as sufficiently dusty to render the room in which it is carried on an unsuitable place, in his opinion, for persons to remain during meal-times.

(*) (‡) (*b*) Mess-room accommodation shall be provided for the workers employed in the processes included in the Schedule, and for such others as are excluded from their own workrooms during meal-times in pursuance of paragraph (*a*) of this Regulation.

(*) (‡) (*c*) This accommodation shall consist of a clean, well-ventilated, and well-lighted room or rooms in which no manufacturing process is carried on; it shall be at or near the factory, and shall be sufficiently large to accommodate all the workers employed in the processes included in the Schedule and all others who are excluded from their own workrooms during meal-times in pursuance of paragraph (*a*) of this Regulation, allowing floor space in accordance with the following scale :—

In mess-rooms for—

6 persons and under	... ...	10½ sq. ft. per person.
Over 6 persons and up to 12	...	7½ " "
" 12 " " 20	...	6 " "
" 20 " " 28	...	5½ " "
" 28 " " any number		5 " "

(*) (‡) (*d*) Provided that if the Inspector of Factories for the district shall certify that in his opinion the special circumstances of any factory are such as to render the provision of mess-room accommodation for all such workers unnecessary, it shall be sufficient to provide accommodation, calculated on the above scale, for such a proportion of all such workers as is named on the certificate of the Inspector; but in no case shall this proportion be less than one-third, subject, in cases of difficulty, to appeal to H.M. Chief Inspector of Factories; and the Inspector for the district shall have the right, at any time, to cancel or amend any such certificate.

(*) (‡) (*e*) All mess-rooms provided in pursuance of this

Regulation shall be furnished with proper tables and seats; provision shall be made for maintaining a proper temperature not below 55 degrees Fahrenheit; and all mess-rooms shall be thoroughly cleaned daily at the occupier's expense.

(*) (‡) (*f*) No person shall be allowed to take into a mess-room any overall, head-covering, or apron, worn in a process included in the Schedule.

() (‡) (*g*) The washing conveniences prescribed by the Regulations shall not be maintained in any mess-room.

(*) (‡) (*h*) A suitable place for the deposit of food shall be provided for each worker using the mess-room. Such provision shall not be made in a room in which any manufacturing process is carried on, and shall be subject in each case to the approval of the Inspector of Factories for the district.

(*) (‡) (*k*) Adequate facilities shall be provided to enable workpeople to heat their food.

(*) (‡) (*l*) A supply of milk, or cocoa made with milk, shall be provided for all women and young persons working in processes included in Part I. of the Schedule, who commence work before 9 a.m. Not less than half a pint shall be provided for each such worker at the expense of the occupier.

7. *Suppression of Dust.*

(*a*) The following processes shall not be carried on without the use of an *efficient exhaust draught* :—

‡ (i.) The fettling of flat ware, whether china or earthenware, by towing or sandpapering, provided that this shall not apply to the occasional finishing of pieces of china or earthenware without the aid of mechanical power ;

‡ (ii.) The sand-sticking of sanitary ware ;

‡ (iii.) Any other process of fettling on a wheel driven by mechanical power, except where :

(*a*) The fettler is fettling, as an occasional operation, only ware of his or her own making ; or

(*b*) The fettling is done wholly with a wet sponge or other moist material ; or

(*c*) The fettling is done by the worker who has made the articles, whilst the latter are still in a moist state.

‡ (iv.) The sifting of clay dust for making tiles or other articles by pressure, except where :

(*a*) This is done in a machine so enclosed as effectually to prevent the escape of dust ; or

(*b*) The material to be sifted is so damp that no dust can be given off.

‡ (v.) The pressing of tiles from clay dust, an exhaust opening being connected with each press ; this clause shall also apply to the pressing from clay dust of articles other than tiles, unless the material is so damp that no dust is given off.

‡ (vi.) The fettling of tiles made from clay dust by pressure, except where the fettling is done wholly on or with damp material ; this clause shall also apply to the fettling of other articles made from clay dust, unless the material is so damp that no dust is given off.

‡ (vii.) The processes of *bedding* and *flinting*.

‡ (viii.) The brushing of earthenware biscuit, unless the process is carried on in a room provided with efficient general mechanical ventilation or other ventilation which is certified by the Inspector of Factories for the district as adequate, having regard to all the circumstances of the case.

‡ (ix.) *Scouring* of biscuit ware which has been fired in powdered flint, except where this is done in machines so enclosed as effectually to prevent the escape of dust.

‡ (x.) Batting of biscuit ware which has been fired in powdered flint.

‡ (xi.) Glaze blowing.

* † (xii.) Ware cleaning after the application of glaze by dipping or other process, except as set forth later in this Regulation.

‡ (xiii.) The preparation of weighing out of *flow material* which yields to dilute hydrochloric acid more than five 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.*

‡ (xiv.) The lawning of dry colours, except where not more than an ounce at a time is lawned for use in painting.

‡ (xv.) Ground laying, including the wiping off of colour after its application to the surface of the ware.

‡ (xvi.) Colour dusting, whether under-glaze or on-glaze, including the wiping off of colour after its application to the surface of the ware.

‡ (xvii.) Colour blowing or aerographing, whether under-glaze or on-glaze, including the wiping off of colour after its application to the surface of the ware.

‡ (xviii.) The making of lithographic transfers, including the wiping off of colour after its application to the surface of the transfer sheets.

(*b*) In the process of mould-making, every bin or similar receptacle used for holding plaster of Paris shall be provided with an *efficient exhaust draught* so arranged as to prevent the escape of plaster of Paris dust into the air of the workplace ; except where a cover is provided for the bin or other receptacle, and the plaster of Paris is conveyed in a sack, the mouth of which is tied and only loosened after it has been placed in the bin or other receptacle.

(*c*) The dry grinding of materials for pottery bodies shall be done either with an *efficient exhaust draught* for the removal of dust, or in machines so enclosed as effectually to prevent the escape of dust; except that it shall not be deemed necessary in pursuance of this Regulation to provide an exhaust draught to remove small amounts of dust given off at the hopper of an enclosed machine in the course of feeding the same, if an outlet into an exhaust duct or to the outside air is fitted to the receptacle into which the powdered material is delivered.

(*d*) In the process of sand-sticking of sanitary ware, suitable provision shall be made for collecting any material which falls on the floor.

‡ (*e*) In the process of making tiles from clay dust by pressure, supplies of material shall be conveyed to the work benches in such a manner as to disperse as little dust as possible into the air; clay dust shall not be carried into any press shops in sacks except where hoppers or similar receptacles are provided for receiving the clay dust, in which case a sack in sound repair shall be used and the mouth of the sack shall be tied and only loosened after it has been placed in the hopper or other receptacle, which shall be provided with a cover. This clause shall also apply to the making from clay dust of articles other than tiles, unless the material is so damp that no dust is given off.

‡ (*f*) After one year from the date on which these Regulations come into force, biscuit flat ware which has been bedded for firing shall not be removed from the saggers after firing, except at a bench fitted with an efficient exhaust appliance for the removal of dust.

‡ (*g*) Flat-knocking and fired-flint-sifting shall be carried on only in enclosed receptacles, which shall be connected with an *efficient exhaust draught* unless so contrived as to prevent effectually the escape of dust.

* (*h*) In the process of ware cleaning of earthenware after the application of glaze by dipping or other process, wherever it is practicable to use damp sponges or other

damp materials they shall be provided in addition to the knife or other instrument, and shall be used.

*† (*k*) Nothing in these Regulations shall render it compulsory to provide an exhaust draught for ware cleaning if this process is carried on entirely with the use of wet materials; or if the ware cleaning be done within 15 minutes after the moment when the glaze was applied; but an *efficient exhaust draught* shall always be provided and used if any dry materials or implements, such as knives or scrapers, are used after the glaze is dry or more than 15 minutes after the moment when the glaze was applied.

* (*l*) In the process of ware cleaning, after the application of glaze by dipping or other process, sufficient arrangements shall be made for any glaze scraped off, which is not removed by the exhaust draught, to fall into water. All water troughs or other receptacles provided in pursuance of this clause shall be cleaned out and supplied with fresh water as often as necessary, and in no case less often than once a week; and no scrapings of glaze shall be allowed to collect in a dry condition on the sides of the water receptacle. Where grids or gratings are fitted over the water trough or other receptacle named in the foregoing paragraph, they shall be kept clean by repeated sponging or wiping with wet material during the time that the process of ware cleaning is being carried on. No boards or other articles shall be placed, even temporarily, on any such water trough, in such a way as to interfere with the efficient use of the trough.

(*m*) In all processes the occupier shall, as far as practicable, adopt efficient measures for the removal of dust and for the prevention of any injurious effects arising therefrom.

(*n*) Every process for which an exhaust draught is prescribed shall be carried on inside a hood or exhaust funnel; provided that, where the occupier can show that this is impracticable, it shall be sufficient if the work is done within the effective range of an exhaust opening.

8. *Respirators.*

(*a*) No person shall be allowed to work without wearing a suitable and efficient respirator, such as a damp sponge tied across the mouth and nostrils, in any of the following processes :—

(i.) The emptying of sacks of plaster of Paris into a bin in a mould-making shop ;

*(ii.) The weighing out, and shovelling, or mixing of unfritted lead compounds, in the preparation or manufacture of frits, glazes or colours containing lead, or any process carried on in a room wherein any such weighing out, shovelling, or mixing has taken place within the previous thirty minutes ;

unless an *efficient exhaust draught* is provided to prevent the escape of dust into the air of the workplace.

(*b*) All respirators required by this Regulation shall be provided and maintained in a cleanly state by the occupier ; and each respirator shall bear the distinguishing mark of the worker to whom it is supplied.

9. *Ventilation.*

‡ (*a*) Every place in which any worker or workers are employed shall be thoroughly ventilated.

‡ (*b*) All workrooms in which articles are left to dry shall be ventilated in such a way as to insure a continuous movement of the air in the room in a direction away from the workers and towards the articles in question.

‡ (*c*) All drying stoves shall be ventilated direct to the outside air by shafts having upward inclinations and terminating vertically, or by louvres in the roof, or by other effective means.

‡ (*d*) All mangles shall be so ventilated as to provide for the maintenance of a flow of air into the hot chamber from the adjoining workroom.

In the case of vertical or "tower" mangles:

(i.) The pipes for heating the mangle shall be fixed above the top of any opening at which workers put in or take off wares; and

(ii.) There shall be a free outlet into the air above, so formed and placed as to insure an outflow whatever the direction of the wind.

‡ (*e*) Fresh air shall, where practicable, be admitted to all workrooms by inlets placed along the sides of the room at a height of as nearly as possible 6 feet above the floor level, hopper opening being used for the purpose wherever possible.

‡ (*f*) Where it is not practicable to provide such fresh air inlets, arrangements shall be made for the entry of an adequate amount of pure air by a flue with apertures at intervals along its length, or other means, which will secure an even distribution of the air through the room.

‡ (*g*) In no case shall fresh air inlets be so arranged that a draught can blow direct from them on to any worker.

‡ (*h*) Wherever the natural air currents are found to be insufficient without assistance to afford thorough ventilation, exhaust fans or other artificial means of creating a current of air shall be provided and maintained in use.

‡ (*k*) Where an exhaust draught is provided for the removal of dust generated in a manufacturing process, precautions shall be taken to prevent dust being drawn into the general atmosphere of the room from other sources of dust in places in the vicinity; communication with such places shall be stopped wherever possible, and the fresh air inlets hereinbefore mentioned shall be so arranged as to insure that no extraneous dust is drawn towards the workers by the exhaust draught.

12. *Floors.*

‡ (*a*) The floors of all slip-houses shall be kept thoroughly clean.

‡ (*b*) In all *potters' shops*, including such drying stoves as

are entered by workpeople, and in all places where the following processes are carried on, viz :—

* Making or mixing of frits, glazes, or colours containing lead,

*† Application of majolica, or other glaze, by blowing, painting, or any other process except dipping,

Preparation, or weighing out, of *flow material*,

Ground laying, including the wiping off of colour after this process,

Colour dusting, Colour blowing — whether on-glaze or under-glaze, including the wiping off of colour after either of these processes,

Colour grinding for colour blowers,

Lithographic transfer making,

the following Regulations shall apply :—

(i.) There shall be provided and maintained :—

(*a*) Either impervious floors ;

(*b*) Or wooden floors with a thoroughly smooth and sound surface, constructed in such a substantial manner as to be free from permanent sag, and maintained in such repair that they can be properly cleaned by a moist method, and that no dust can fall through into rooms below.

(ii.) The floors, when the rooms are in use, shall be thoroughly cleaned daily, by a moist method, by an adult male after work has ceased for the day, and before 3 a.m. next morning ; except that in rooms in which ground laying is done, the cleaning prescribed by this Regulation may be done before work commences in the morning, provided that in no case shall any work be carried on in the room within one hour after such cleaning as aforesaid has ceased.

(iii.) Scraps of clay and other débris, including any which have collected under benches, shall not be allowed to accumulate unduly, and all such scraps and débris shall be carried out at least once a day. Scraps of clay in *potters' shops* shall be damped before being carried out.

In all drying stoves which are entered by workpeople, boxes shall be provided for the reception of broken or waste clay ware.

(iv.) Suitable provisions shall be made for the storage of all moulds when not in use. In existing installations, the tops of drying stoves shall not be used for this purpose unless it is shown to the satisfaction of the Inspector of Factories for the district that no other suitable place is available. In any new erections, suitable provisions shall be made without utilizing the tops of stoves for this purpose, unless the top of the stove is made into a separate chamber.

‡ (*c*) The floors of all biscuit placing and glost placing shops shall be impervious, even floors, of brick, flag or similar hard material, and shall be kept in good repair ; they shall be thoroughly sprinkled and swept by an adult male whenever the work of setting in an oven has ceased, and under any circumstances at least once a day.

*†‡ (*d*) The floors of all dipping houses, dippers' drying rooms, and ware cleaning rooms shall be washable impervious floors, and shall be thoroughly cleaned daily by an adult male, after work has ceased for the day, with a sufficient supply of water and a mop or similar implement ; provided that, in the case of china dippers' drying rooms, this cleaning may be done before work commences in the morning, instead of after work has ceased for the day.

The floors of all dipping houses, dippers' drying rooms, and ware cleaning rooms erected after the date on which these Regulations come into force, shall be properly sloped towards a drain.

‡ (*e*) In any new erection where steam pipes are used for heating a drying stove, dippers' drying room, or any place where articles are left to dry, the pipes shall, if possible, be fixed in the form of a rack of horizontal pipes

in a vertical plane. Where this is impossible, the pipes shall be fixed in such a position as to allow a thorough cleaning under and around them.

In existing installations, if it is impracticable to comply with the preceding paragraph, the steam pipes shall be enclosed in a box in such a manner as to permit of the thorough cleaning of all parts of the box on which persons may walk or stand, and adequate measures shall be taken to prevent dust escaping from within the box. Slides, drawers, trap-doors or other contrivances shall be provided wherever necessary to facilitate cleaning under pipes.

All stillages shall be so arranged as to allow the floor to be thoroughly cleaned underneath them.

(*f*) In all *workrooms* not specially mentioned in the foregoing paragraphs of this Regulation, the following Regulations shall apply :—

All floors shall be maintained in such repair that they can be properly cleaned by a moist method, and shall be so cleaned daily.

All ashes, dirt or other débris, including any which have accumulated under benches, shall be carried out daily.

(*g*) The above requirement as to the daily cleaning of floors by a moist method shall not apply to places where saggers, retorts or crucibles are made, or to those parts of floors on or immediately above which articles of *pottery* are necessarily left overnight, if adequate provision is made for the cleaning of the floors as soon as the articles are removed.

13. *Work Benches.*

The following Regulations shall apply to work benches in *potters' shops*, and in places where processes named in the Schedule are carried on :—

(*) ‡ (*a*) Work benches, if not covered with sheet metal or constructed with an impervious surface, shall be strongly and solidly constructed of closely jointed timber, and the surface of the work benches shall be well maintained.

(*) ‡ (*b*) All work benches in use shall be thoroughly cleaned daily by a moist method.

14. *Lead House.*

* (*a*) Raw lead compounds shall not be handled except with at least 5 per cent. of added moisture.

* (*b*) They shall, further, be kept in their original packages until weighed out, and the tub or other receptacle containing them shall be so fitted either with a cover or a damp screen as to prevent the issue of any lead dust from its mouth.

*‡ (*c*) In every lead-house, except such as are used for less than eight hours in any week, a special lavatory basin with a supply of hot and cold water, nail brush, soap and towel shall be provided and maintained; and a solution of soluble sulphides shall be provided in which workers in the lead house shall rinse their hands after washing so as to show if they are free from lead.

15. *Dipping House, etc.*

*† (*a*) In dipping houses, all parts of walls sufficiently near to any dipping tub to be splashed with glaze shall be tiled, or painted with washable paint, or otherwise treated in such a manner as to permit of thorough cleaning by a wet process.

*† (*b*) The above-named parts of walls, as well as the dipping tubs and any other objects which are splashed with glaze, shall be thoroughly cleaned daily by a wet process.

(*c*) All dipping houses and ware cleaning rooms shall be well lighted; neither dipping nor ware cleaning shall be done in places which, in ordinary fine weather, are dependent on borrowed light or artificial light during the hours of daylight.

16. *Threading-up.*

*†‡ In the process of threading-up, rubber or other washers, used to keep articles apart when being dipped, shall be thoroughly washed in a colander after each dipping. Wires shall also be washed after each dipping.

17. *Boards.*

* (*a*) Every board on which dipped ware has been placed shall, on each occasion after it has been used for one set of articles and before being used for another, be thoroughly cleaned with clean water by an adult male.

* (*b*) "Nailed" or "pegged" boards shall be cleaned under a strong jet of water; no new boards of this description shall be introduced except where necessary to hold china furniture or other special articles which cannot be carried on ribbed or plain boards.

(*) (‡) (*c*) Boards for use in processes included in Part I. of the Schedule shall be clearly marked by painting them red at the ends and for a distance of at least six inches from each end of the board on both sides, so as to distinguish them from other boards which do not come into contact with lead. Boards so marked shall not be used in any department unless they have been thoroughly cleaned, and shall not be used in the clay department under any circumstances. Boards not so marked shall not be taken into any place where a process included in Part I. of the Schedule is carried on; but this shall not apply to placing shops in which both biscuit and glost ware are being placed, provided that the boards used for biscuit ware are kept separate and returned to their respective departments without any contact with the boards used for glost ware.

18. *Mangles.*

*‡ All mangle shelves shall be thoroughly cleaned by a wet process by an adult male on a fixed day in each week, after work has ceased for the day. The day on which this

cleaning is to take place shall be fixed by entry in the register kept in pursuance of Regulation 3.

19. *Thimble Picking.*

(*) (†) ‡ All material collected from floors or work benches shall be riddled in an enclosed receptacle before it is taken to a thimble picking room.

20. *Majolica Painting.*

The following Regulations shall apply to the process of *majolica painting* :—

*‡ (*a*) A sponge and bowl of clean water, to rinse the fingers, shall be provided on the work bench beside each person employed in *majolica painting.*

*‡ (*b*) In all *majolica painting* shops where there is no adjoining lavatory accommodation, there shall be provided in the room a lavatory sink with a tap, a constant supply of water, and towels.

*‡ (*c*) All splashes of glaze falling on the benches, or surrounding objects, shall be immediately removed with a wet sponge or other wet material.

*‡ (*d*) No floor or work bench shall be deemed to have been thoroughly cleaned, in accordance with Regulation 12 or 13, unless all splashes of glaze have been completely removed.

*‡ (*e*) Mottling, or any similar method of applying glaze, shall only be carried on under the Regulations applying to *majolica painting.*

*‡ (*f*) All cleaning and scraping, including panel-cutting, after *majolica* dipping, *painting*, or blowing, shall be deemed to be ware cleaning, and shall only be done in compliance with the rules for the latter process.

21. *Cotton-Wool in Ground Laying, Colour Dusting, and Lithographic Transfer Making.*

‡ All pieces of cotton-wool or similar materials which have been used in the process of ground laying, or colour dusting, or lithographic transfer making, shall be kept in a proper receptacle. All pieces of waste cotton-wool or similar materials which have been so used shall be immediately burnt.

22. *Aerographing.*

‡ (*a*) No short-sighted person shall be employed to do glaze or colour blowing, unless wearing suitable glasses. No person shall be employed as a glaze or colour blower, unless the *Surgeon* has *entered in the health register* a certificate stating that he has examined the worker's sight and is satisfied that he or she can be so employed without breach of this Regulation.

‡ (*b*) All hoods in which the blowing of glaze or colour is carried on shall be thoroughly cleaned daily by a wet process.

‡ (*c*) Glaze or colour blowing shall not be done with the mouth.

‡ (*d*) Decoration on unfired clay ware by means of coloured clay slips shall not be regarded as colour blowing for the purposes of any of the Regulations applying specially to the latter process.

23. *Lithographic Transfer Making.*

‡ Machines used in lithographic transfer making shall not be brushed down, but shall be cleaned either—

(*a*) with moist materials, such as oily rags, in such a manner as not to disperse any dust into the air; or

(*b*) by means of an exhaust current of air, such as that afforded by a vacuum-cleaner.

24. *Separation of Processes.*

(*) (†) ‡ (*a*) *Thimble picking* or threading-up shall not be carried on except in a place sufficiently separated from any process included in the Schedule.

(*) (‡) (*b*) When a process included in the Schedule is being carried on in a room where other work is also done.

(i.) Either the place where the scheduled process is carried on shall be screened off from the rest of the room by a partition not less than eight feet high,

(ii.) Or all persons working in the room shall be deemed to be persons employed in the scheduled process.

25. *Hours of Employment.*

(*a*) No person employed in a process included in Part I. of the Schedule, except in *glost placing* and lithographic transfer making, shall be employed for more than four hours without an interval of at least half an hour for a meal.

No person shall be employed in the process of *glost placing* or in the process of lithographic transfer making for more than $4\frac{1}{2}$ hours, or in any other process for more than 5 hours, without an interval of at least half an hour for a meal.

(*) (‡) (*b*) No woman or young person who is employed in any process included in Part I. of the Schedule shall be employed in the factory in any capacity for more than 48 hours in any week.

(*) (*c*) No adult male who is employed as a dipper, dipper's assistant, or ware cleaner shall be employed in the factory in any capacity for more than 48 hours in any week, provided that where such an adult male worker has been employed in a process included in Part I. of the Schedule, for not more than 8 hours in any one day or 30 hours in all in a week, he may be employed during the same week on work not involving contact with lead up to a limit of 54 hours for that week.

(*) (*d*) No adult male who is employed as a glost placer shall be employed in the factory in any capacity for more than 54 hours in any week.

(*) (*e*) Except that it shall be permissible to employ adult male dippers, dippers' assistants, ware cleaners, and glost placers overtime in addition to the prescribed weekly periods of 48 and 54 hours; provided that such overtime shall not, in any factory to which these Regulations apply, exceed 4 hours in any week, or 36 hours in any period of twelve months. The occupier shall enter in the prescribed register particulars of all such overtime, and shall also send notice, with the prescribed particulars, to the Inspector of Factories for the district, before eight o'clock in the evening of any day when a man is employed overtime in pursuance of this exception. An occupier who avails himself of this exception shall, if called upon, produce to the Inspector of Factories for the district evidence of press of orders or other circumstance rendering the overtime necessary.

Adult male dippers, ware cleaners, and glost placers may be employed, in addition to the above-named hours, as sitters-up with an oven after the termination of the period of employment on one day in the week and before the commencement of the period of employment on the next day; provided that no such worker shall be employed in any capacity within 12 hours of the cessation of the period of sitting-up.

(*f*) In *potters' shops*, and in any place where towing or any other dusty process is carried on, including any process for which a certificate by an Inspector of Factories has been given in pursuance of the first paragraph of Regulation 6, no women or young person shall be employed for more than 9½ hours in any day or for more than 6½ hours on Saturday.

(*g*) All the above weekly and daily periods shall be the maximum permissible periods of actual work, exclusive of meal-times.

26. *Affixing of Regulations.*

(*) (‡) In addition to the printed copies of these Regulations required to be kept posted up in pursuance of Section 86 of the Factory and Workshop Act, 1901,* there shall be kept constantly affixed in every *potters' shop* and in every place in which any process included in the Schedule is carried on, a notice printed in bold type so that it can be easily read, setting forth those portions of the Regulations which apply to that particular work-place.

27. *Observance of Regulations.*

(*a*) A person or persons shall be appointed who shall see to the observance, throughout the factory, of the Regulations, and whose duty it shall be to carry out systematic inspection of the working of all the Regulations in the departments for which they are individually responsible. The names of the persons so appointed shall be recorded in the register.

(*b*) Each person so appointed shall be a competent person fully conversant with the meaning and application of the Regulations in so far as they concern the departments for which he is responsible. He shall keep in the factory a book in which he shall record any breach of the Regulations, or any failure of the apparatus (fans, etc.) needed for carrying out the provisions, that he may have observed, or that may have been brought to his notice within the preceding 24 hours, together with a statement of the steps then taken to remedy such defects or to prevent the recurrence of such breach. Each entry in such book shall be dated and initialled by the person appointed, who at the end of each week shall make a further entry stating that the inspection required by paragraph (*a*) has been carried out, and that all the defects observed or brought to his notice have been recorded in the book. Such book shall be kept in the factory for at least six months after the latest entry therein.

* 1 Edw. 7, c. 22.

(*c*) Accurate extracts, clearly and legibly expressed, shall be made of these entries once a week, and signed by the occupier or someone whom he may appoint, and displayed during the following week in a conspicuous place in the departments to which they refer, and copies of all such extracts shall for the same time be displayed in a conspicuous place in the mess-rooms.

28. *Samples for Analysis.*

(*a*) The occupier shall allow any of His Majesty's Inspectors of Factories to take at any time sufficient samples for analysis of any material in use or mixed for use.

(*b*) Provided that the occupier may at the time when the sample is taken, and on providing the necessary appliances, require the Inspector to take, seal, and deliver to him a duplicate sample.

(*c*) But no analytical result shall be disclosed or published in any way except such as shall be necessary to establish a breach of these Regulations.

Part II.—Duties of Persons Employed.

29. *Periodical Examinations.*

(*) (†) (‡) (*a*) All persons employed in the processes included in the Schedule shall present themselves at the appointed times for examination by the *Surgeon* as provided in Regulation 2.

(*) (†) (‡) (*b*) No person after *suspension* shall work in any process in which examination by the *Surgeon* is required by these Regulations without a certificate of *permission to work.*

30. *Overalls, etc.*

(*) (‡) (*a*) All persons employed in any process included in the Schedule shall, when at work, wear overalls, head-coverings, and aprons, as required by Regulation 4. The said overalls, head-coverings, and aprons shall not be worn outside the factory or workshop, and shall not be removed therefrom except for the purpose of being washed or repaired. No overalls, head-coverings or aprons, provided in pursuance of Regulation 4, shall, under any circumstances, be taken to a worker's home.

(*) (‡) (*b*) The head-coverings provided in accordance with Regulation 4 shall be worn in such a manner as effectually to protect the hair from dust, and the hair must be so arranged as to permit of this.

(*) (‡) (*c*) The overalls, head-coverings, and aprons, when not being worn, and clothing put off during working hours, shall be deposited in the respective places provided by the occupier for such purposes under these Regulations.

(*d*) Respirators shall be worn as required by Regulation 8.

31. *Food.*

(*) (‡) (*a*) No person shall introduce, keep, prepare, or partake of any food, drink, or tobacco, or remain during meal-times in any place in which is carried on any process included in the Schedule, or the process of towing, or the process of tile-making by the compression of dust, or any other process which the Inspector of Factories for the district shall certify as sufficiently dusty to render the room in which it is carried on an unsuitable place, in his opinion, for persons to remain during meal-times.

(*) (‡) (*b*) Every worker for whom milk or cocoa is provided in accordance with Regulation 6 shall drink the same, unless a medical certificate is produced showing cause for exemption from this requirement.

32. *Ventilation—Dust.*

No person shall in any way interfere, without the knowledge and concurrence of the occupier or manager, with the means and appliances provided by the employers for ventilation, and for the removal of dust.

33. *Washing.*

(*) (‡) (*a*) No person employed in any process included in the Schedule shall leave the works or partake of meals without previously and carefully cleaning and washing his or her hands.

(*) (‡) (*b*) No person employed shall remove or damage the washing basins or conveniences provided under these Regulations.

34. *Cleaning of Work Places.*

The persons appointed by the occupiers shall clean the several floors, walls, work benches, appliances and other objects regularly as prescribed in these Regulations.

35. *Boards.*

* (*a*) The boards used in the dipping house, dippers' drying room, or glost placing shop shall not be used in any other department, except after being cleaned, as directed in Regulation 17.

* (*b*) No board on which dipped ware has been placed shall be used for a second set of dipped articles until it has been thoroughly cleaned, in accordance with Regulation 17.

Where a convenient grid or other suitable contrivance is provided for depositing such boards after use and before being cleaned, the worker who has removed the ware from any such board shall place the board thereon.

(*) (*c*) Boards which are marked for use in lead processes shall not be used in any department unless they have been thoroughly cleaned, and shall not be used in the clay departments under any circumstances.

36. *Avoidance of Dust, etc.*

Every worker shall so conduct his or her work as to comply strictly with these Regulations, and to avoid, as far as practicable, making or scattering dust, or refuse, or causing accumulation of such.

R. McKenna,
One of His Majesty's Principal
Secretaries of State.

Home Office, Whitehall.
2nd January, 1913.

SCHEDULE.

PART I.—LEAD PROCESSES.

* (*a*) Making or mixing of frits, glazes, or colours containing lead.

* (*b*) Dipping or other process carried on 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 cranks or similar articles prior to their transfer to saggers or kilns for the glost firing.

* (*g*) *Glost placing*.

‡ (*h*) Washing of saggers with a wash which yields to dilute hydrochloric acid more than five 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 dusting } whether on-glaze or under-glaze, including the wiping off of colour after either of these processes.
‡ (*n*) Colour blowing }

‡ (*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.

PART II.—OTHER PROCESSES.

‡ (*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.

APPENDIX.

Codes of Special Rules established under the Factory and Workshop Acts, 1891 and 1895.

1. For the Manufacture of White Lead.

In these Rules "persons employed in lead process" means a person who is employed in any work or process involving exposure to white lead, or to lead or lead compounds used in its manufacture, or who is admitted to any room or part of the factory where such process is carried on.

Any approval given by the Chief Inspector of Factories in pursuance of Rules 2, 4, 6, 9, or 12 shall be given in writing, and may at any time be revoked by notice in writing signed by him.

Duties oj Occupiers.

1. On and after July 1st, 1899, no part of a white lead factory shall be constructed, structurally altered, or newly used, for any process in which white lead is manufactured or prepared for sale, unless the plans have previously been submitted to and approved in writing by the Chief Inspector of Factories.

2. (*a*) Every stack shall be provided with a standpipe and movable hose, and an adequate supply of water distributed by a rose.

(*b*) Every white bed shall, on the removal of the covering boards, be effectually damped by the means mentioned above.

Where it is shown to the satisfaction of the Chief Inspector of Factories that there is no available public water service in the district, it shall be a sufficient compliance with this Rule if each white bed is, on the removal of the covering boards, effectually damped by means of a watering can.

3. Where white lead is made by the chamber process, the chamber shall be kept moist while the process is in operation, and the corrosions shall be effectually moistened before the chamber is emptied.

4. (*a*) Corrosions shall not be carried except in trays of impervious material.

(*b*) No person shall be allowed to carry on his head or shoulder a tray of corrosions which has been allowed to rest directly upon the corrosions, or upon any surface where there is white lead.

(*c*)* All corrosions before being put into the rollers or washbecks, shall be effectually damped, either by dipping the tray containing them in a trough of water or by some other method approved by the Chief Inspector of Factories.

5. The flooring round the rollers shall either be of smooth cement or be covered with sheet lead, and shall be kept constantly moist.

6. On and after January 1st, 1901, except as hereinafter provided—

(*a*) Every stove shall have a window, or windows, with a total area of not less than 8 square feet, made to open, and so placed as to admit of effectual through ventilation.

(*b*) In no stove shall bowls be placed on a rack which is more than 10 feet from the floor.

(*c*) Each bowl shall rest upon the rack, and not upon another bowl.

(*d*) No stove shall be entered for the purpose of drawing until the temperature at a height of 5 feet from the floor has fallen either to 70° F., or to a point not more than 10° F. above the temperature of the air outside.

(*e*) In drawing any stove or part of a stove there shall not be more than one stage or standing place above the level of the floor.

Provided that if the Chief Inspector approves of any other means of ventilating a stove, as allowing of effectual

* The following addition to Rule 4 (*c*) is in force in one works:—
"Provided that the damping of the corrosions shall not be required if efficient exhaust ventilation is applied at the washbecks in such manner as to prevent the inhalation of dust by the workers when putting the corrosions into the washbecks or rollers."

through ventilation, such means may be adopted, notwithstanding paragraph (*a*) of this rule ; and if he approves of any other method of setting and drawing the stoves, as effectually preventing white lead from falling upon any worker, such method may be followed, notwithstanding paragraphs (*b*) and (*c*) of this Rule.

7. No person shall be employed in drawing Dutch stoves on more than two days in any week.

8. No dry white lead shall be deposited in any place that is not provided either with a cover or with a fan effectually removing the dust from the worker.

9. On and after January 1st, 1900, the packing of dry white lead shall be done only under conditions which secure the effectual removal of dust, either by exhaust fans or by other efficient means approved in each case by the Chief Inspector of Factories.

This rule shall not apply where the packing is effected by mechanical means entirely closed in.

10. The floor of any place where packing of dry white lead is carried on shall be of cement, or of stone set in cement.

11. No woman shall be employed or allowed in the white beds, rollers, washbecks, or stoves, or in any place where dry white lead is packed, or in other work exposing her to white lead dust.

12. (*a*) A duly qualified medical practitioner (in these Rules referred to as the "Appointed Surgeon") shall be appointed by the occupier for each factory, such appointment to be subject to the approval of the Chief Inspector.

(*b*) No person shall be employed in a lead process for more than a week without a certificate of fitness granted after examination by the Appointed Surgeon.

(*c*)* Every person employed in a lead process shall be

* The following Rule is in force in one works in substitution for Rule 12 (*c*) :—

> "Every person employed in a lead process shall once in each calendar month, on a date of which notice shall be given to every person, be examined by the Appointed Surgeon, who shall have power to suspend from employment in any lead process."

examined once a week by the Appointed Surgeon, who shall have power to order suspension from employment in any place or process.

(*d*) No person after such suspension shall be employed in a lead process without the written sanction of the Appointed Surgeon.

(*e*) A Register in a form approved by the Chief Inspector of Factories shall be kept, and shall contain a list of all persons employed in lead processes. The Appointed Surgeon will enter in the Register the dates and results of his examinations of the persons employed, and particulars of any directions given by him. The Register shall be produced at any time when required by H.M. Inspectors of Factories or by the Certifying Surgeon or by the Appointed Surgeon.

13. Upon any person employed in a lead process complaining of being unwell, the occupier shall, with the least possible delay, give an order upon a duly qualified medical practitioner.

14. The occupier shall provide and maintain sufficient and suitable respirators, overalls, and head-coverings, and shall cause them to be worn as directed in Rule 29.

At the end of every day's work they shall be collected and kept in proper custody in a suitable place set apart for the purpose.

They shall be thoroughly washed or renewed every week ; and those which have been used in the stoves, and all respirators, shall be washed or renewed daily.

15. The occupier shall provide and maintain a dining-room and a cloak-room in which workers can deposit clothing put off during working hours.

16. No person employed in a lead process shall be allowed to prepare or partake of any food or drink except in the dining-room or kitchen.

17. A supply of a suitable sanitary drink, to be approved by the Appointed Surgeon, shall be kept for the use of the workers.

18. The occupier shall provide and maintain a lavatory

for the use of the workers, with soap, nail brushes, and at least one lavatory basin for every five persons employed. Each such basin shall be fitted with a waste pipe. There shall be a constant supply of hot and cold water laid on, except where there is no available public water service, in which case the provision of hot and cold water shall be such as shall satisfy the Inspector in charge of the district.*

The lavatory shall be thoroughly cleaned and supplied with clean towels after every meal.

There shall, in addition, be means of washing in close proximity to the workers of each department, if required by notice in writing from the Inspector in charge of the district.

There shall be facilities, to the satisfaction of the Inspector in charge of the district, for the workers to wash out their mouths.

19. Before each meal, and before the end of the day's work, at least ten minutes in addition to the regular meal times, shall be allowed to each worker for washing.

A notice to this effect shall be affixed in each department.

* The following Rule is in force in certain works in substitution for paragraph 1 of Rule 18 :—

"The occupier shall provide and maintain in a cleanly state and in good repair for the use of persons employed a lavatory containing either—

"(*a*) At least one lavatory basin for every five such persons, fitted with a waste pipe, or placed in a trough having a waste pipe, and having a constant supply of hot and cold water, or warm water, laid on; or

"(*b*) Troughs of enamel or similar smooth impervious material, fitted with waste pipes without plugs, and having a constant supply of hot and cold water, or warm water, laid on. The length of such troughs shall be in a proportion of not less than 2 feet for every five persons employed.

"He shall also provide in the lavatory, soap, nail brushes, and a sufficient supply of towels."

20.* The occupier shall provide and maintain sufficient baths and dressing rooms for all persons employed in lead processes, with hot and cold water, soap, and towels, and shall cause each such person to take a bath once a week at the factory.

A bath register shall be kept, containing a list of all persons employed in lead processes, and an entry of the date when each person takes a bath.

This register shall be produced at any time when re-required by H.M. Inspectors of Factories or by the Certifying Surgeon or by the Appointed Surgeon.

21. The dressing-rooms, baths, and w.c.'s shall be cleaned daily.

22. The floor of each workroom shall be cleaned daily, after being thoroughly damped.

Duties of Persons Employed.

23. No person shall strip a white bed or empty a chamber without previously effectually damping as directed in Rules 2 and 3.

24. No persons shall carry corrosions, or put them into the rollers or washbecks, otherwise than as permitted by Rule 4.

25. No person shall set or draw a stove otherwise than as permitted by Rules 6 and 7.

26. No person shall deposit or pack dry white lead otherwise than as permitted by Rules 8 and 9.

27. Every person employed in a lead process shall present himself at the appointed times for examination by the Appointed Surgeon, as provided in Rule 12.

* The following proviso to Rule 20 is in force in one works :—

"Provided that this Rule shall not apply if the Chief Inspector of Factories approves the use of the local public baths when conveniently near, under the conditions (if any) named in such approval."

The following marks used in the Health Register of Lead Factories are those recommended by the Home Office to Certifying Factory Surgeons and to medical men appointed to lead works :

$\frac{1}{a}$	means	worker passed without comment.
$\frac{2}{a}$	,,	a blue line on the gums, or an indication thereof.
bc	,,	increasing impairment of general health.
c	,,	pregnancy without suspension.
d	,,	suspension or transfer for reasons other than lead.
x	,,	carelessness or unsuitability for lead work.
dx	,,	suspension for such reasons.
$\frac{1}{b}$	,,	anæmia.

INDEX

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